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Bae et al.

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(54) **METHOD AND APPARATUS FOR TESTING FLAT DISPLAY APPARATUS**

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G01R 31/28 (2006.01)
G01R 31/26 (2006.01)

(52) **U.S. Cl.** **324/529**; 324/770; 324/158.1; 702/59

(58) **Field of Classification Search** 324/529, 324/770, 750–765
See application file for complete search history.

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(57) **ABSTRACT**

A method and apparatus tests a flat display device to inspect for shorts and open circuits in a signal wire by using a magnetic sensor. The inspection method and apparatus scans the magnetic sensor along signal wires in a scan direction crossing multiple signal wires and detects at least one of a short or an open circuit in the signal wires based on current detected by the magnetic sensor.

24 Claims, 18 Drawing Sheets

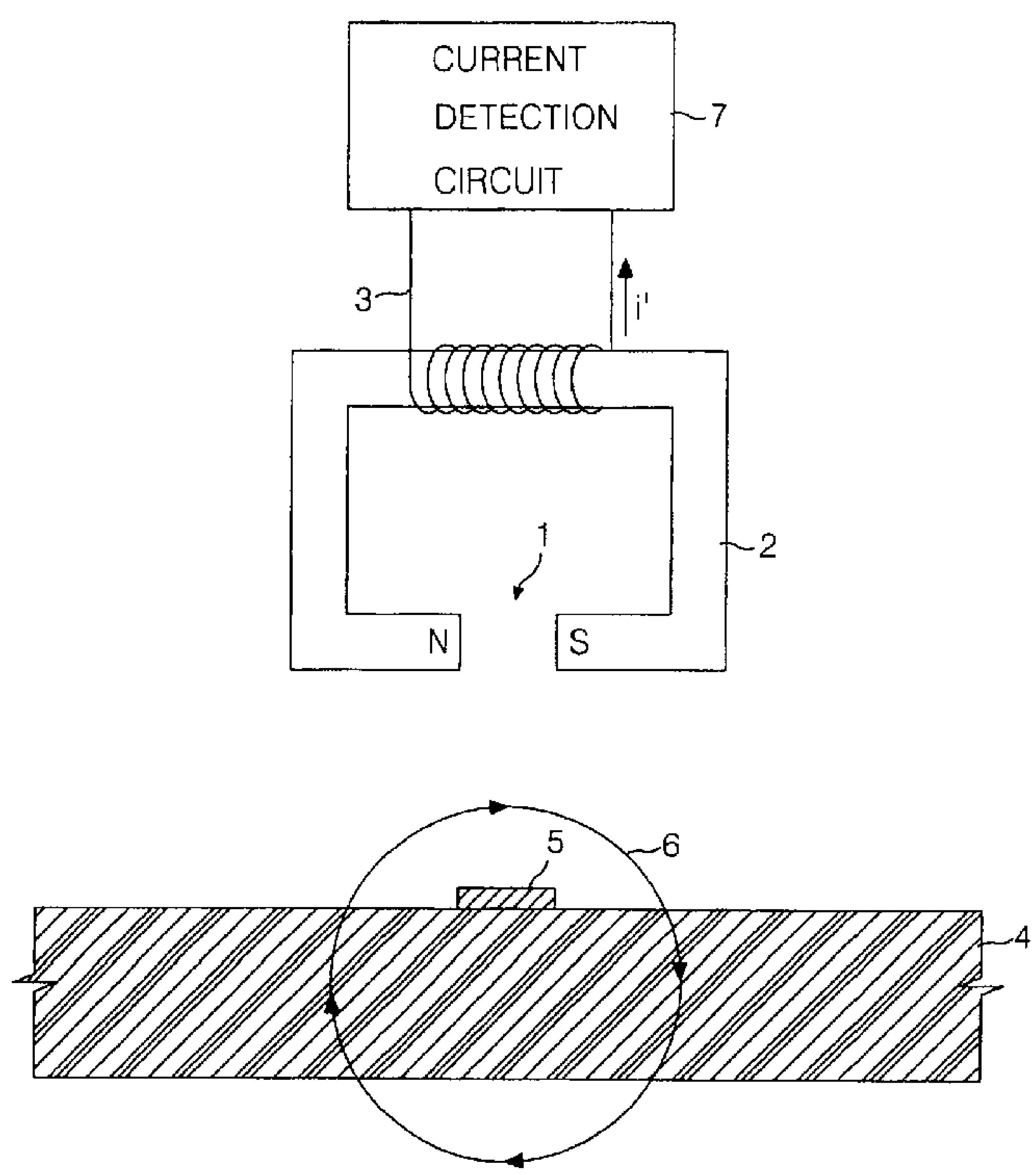


FIG. 1
RELATED ART

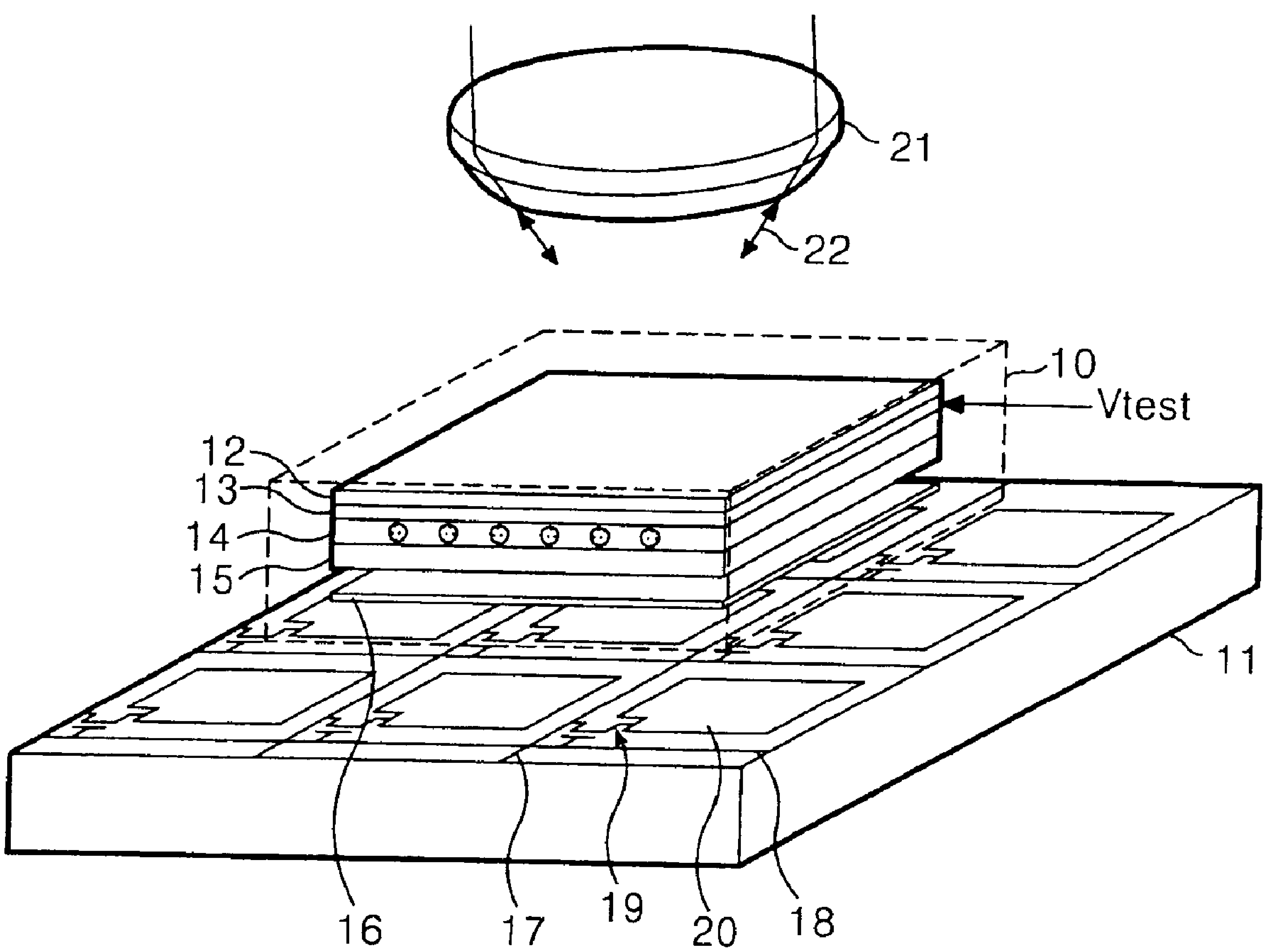


FIG. 2
RELATED ART

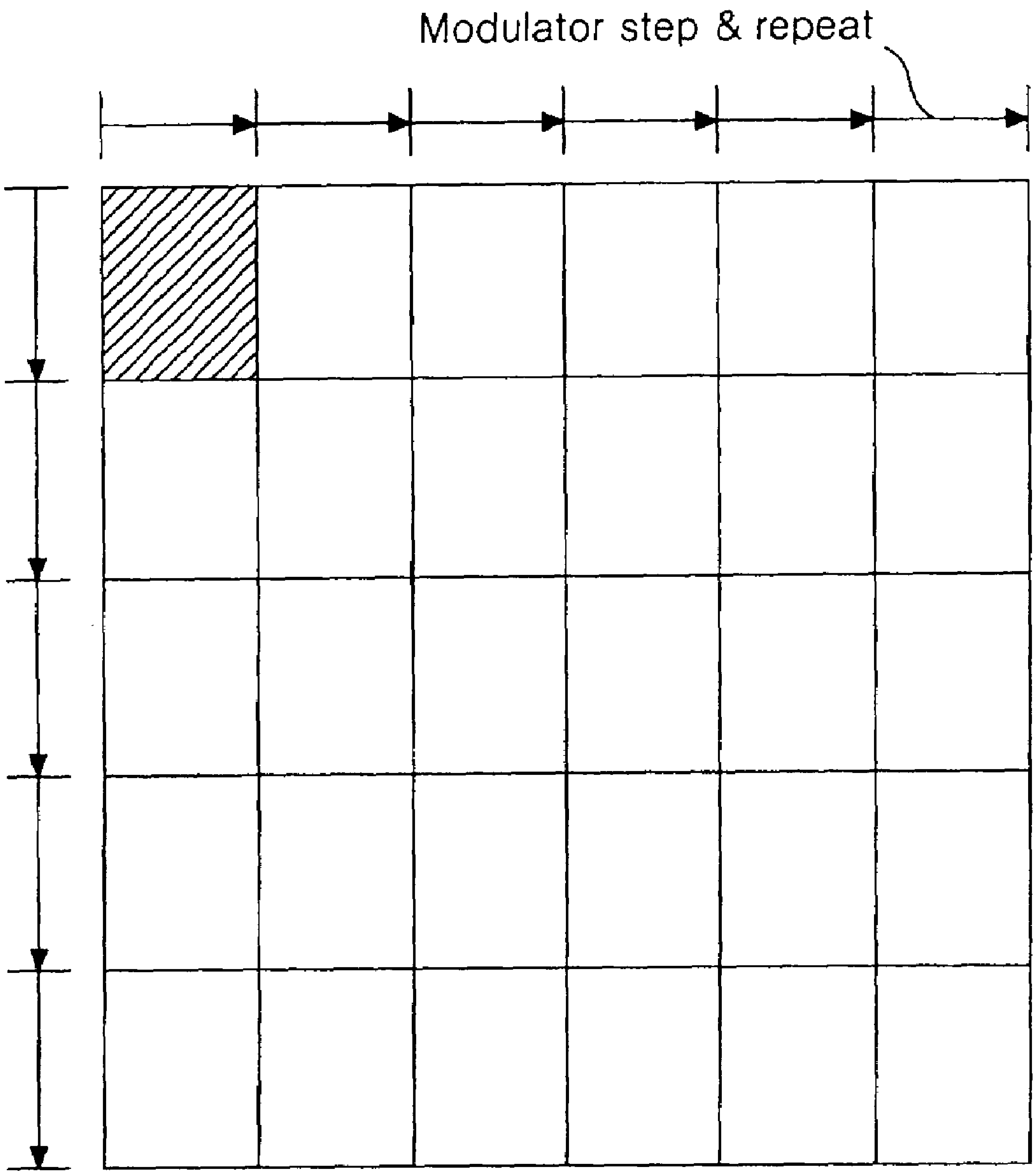


FIG.3

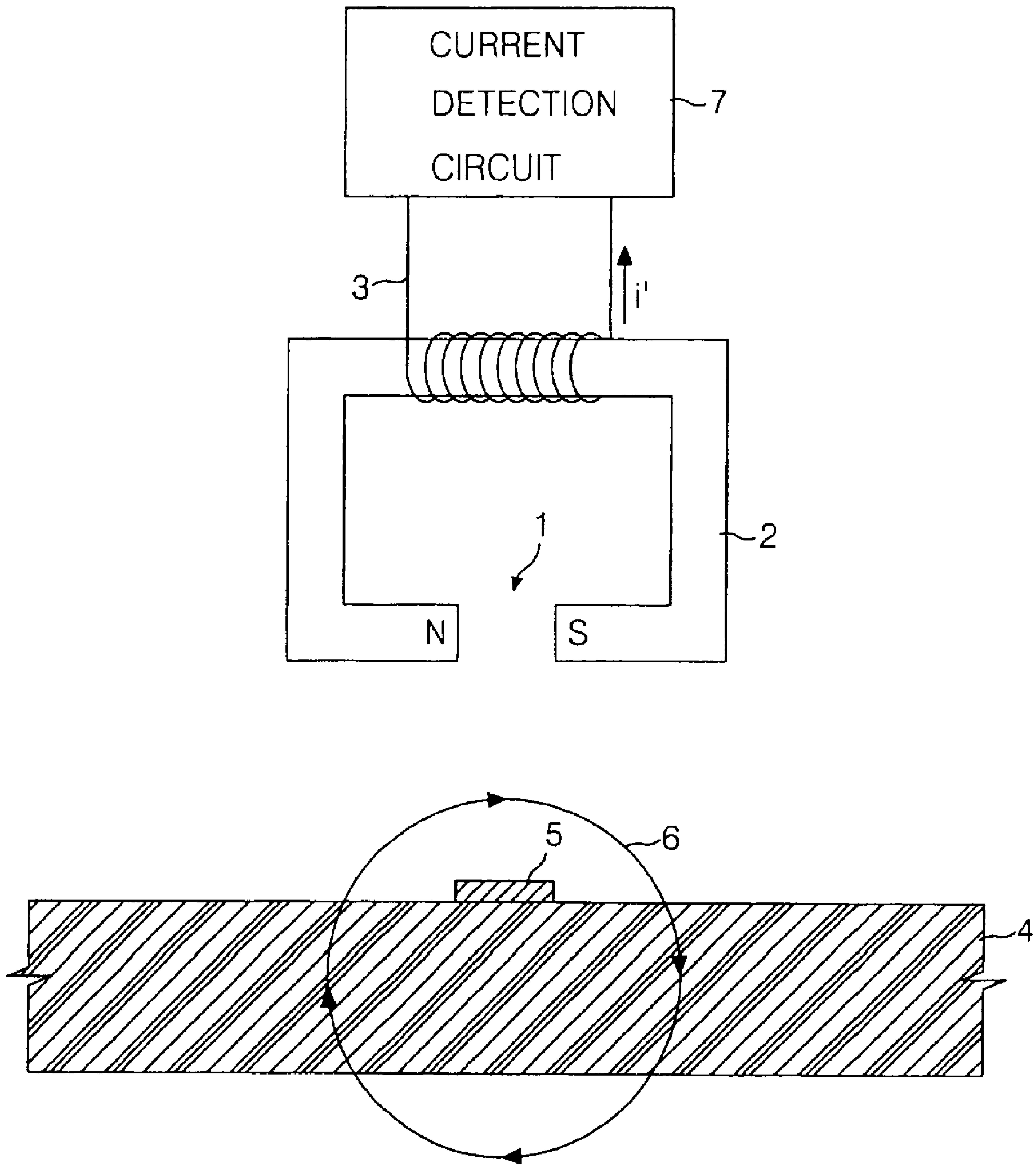
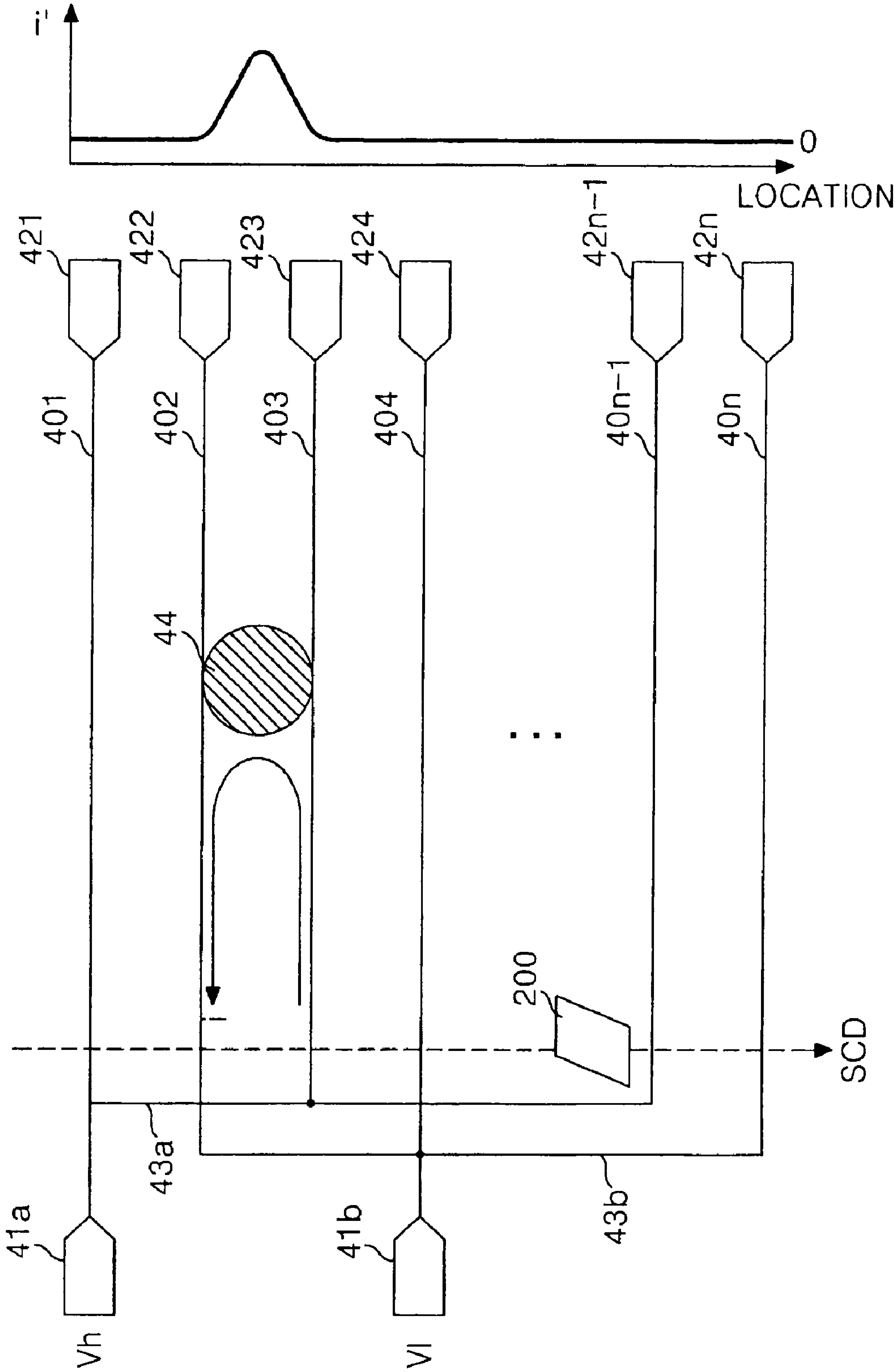


FIG. 4



i'
0
LOCATION
421
422
423
424
42n-1
42n
401
402
403
404
40n-1
40n
44
I
200
SCD
43a
43b
41a
41b
Vh
Vl

FIG.5

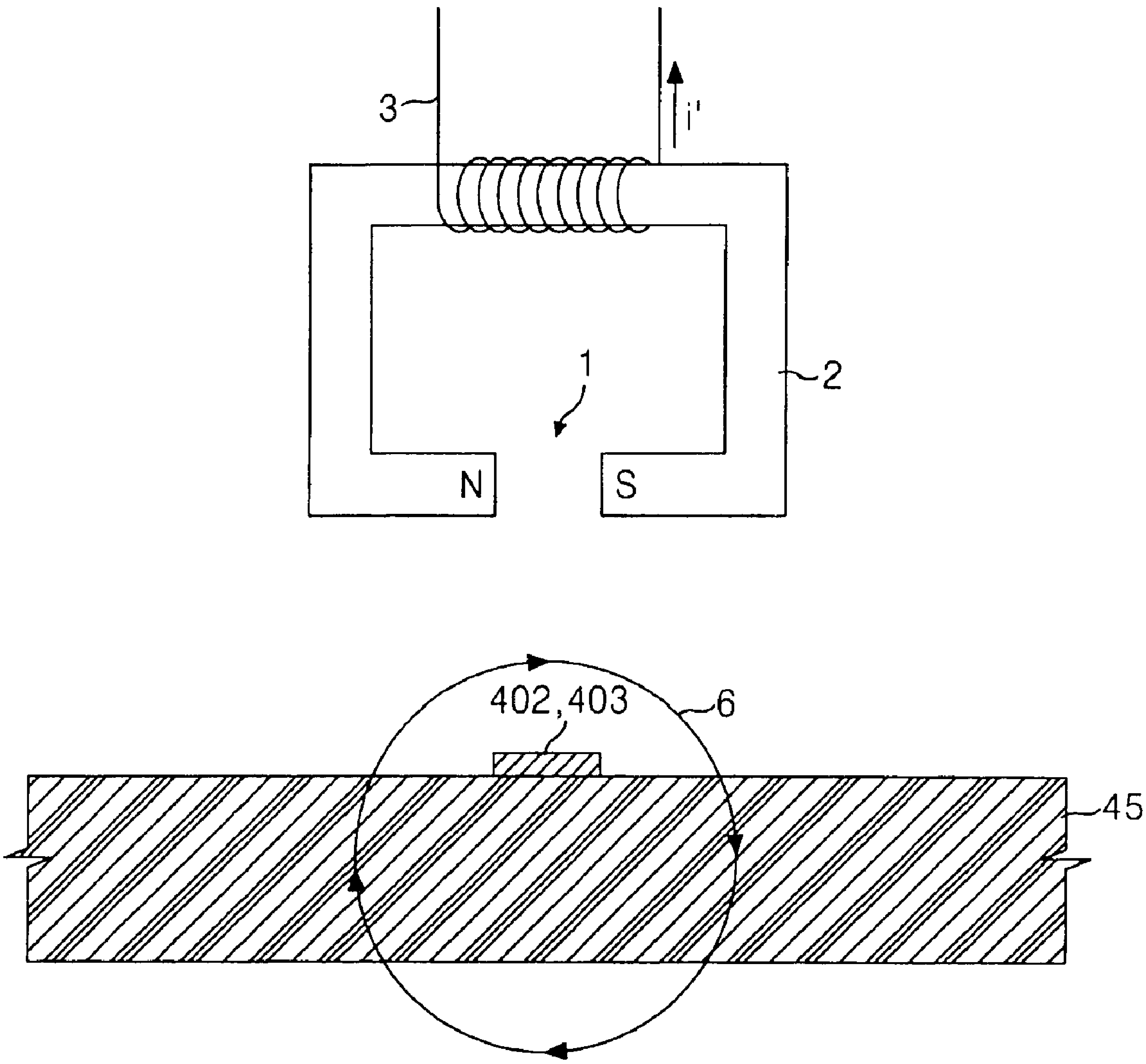


FIG.6

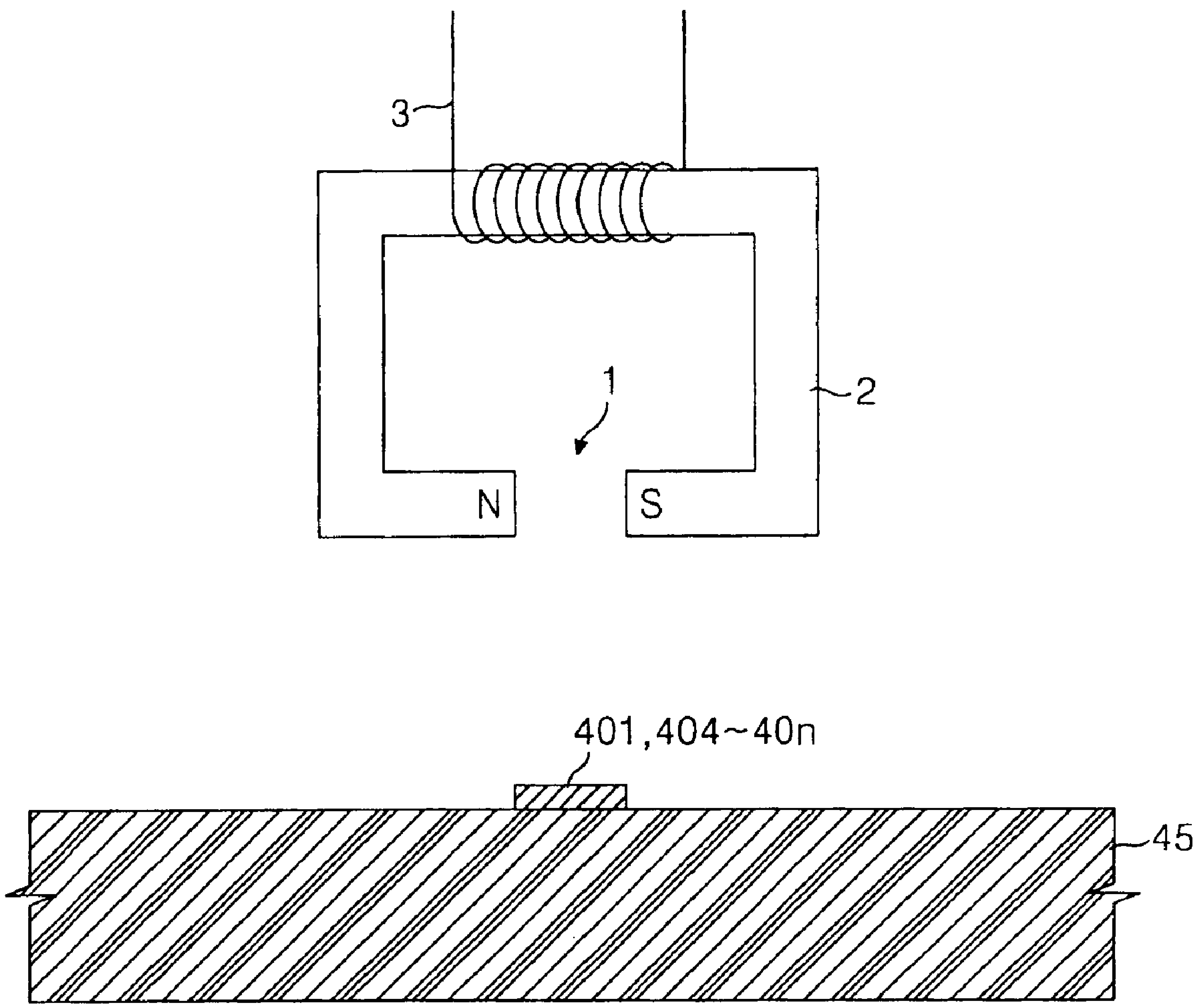
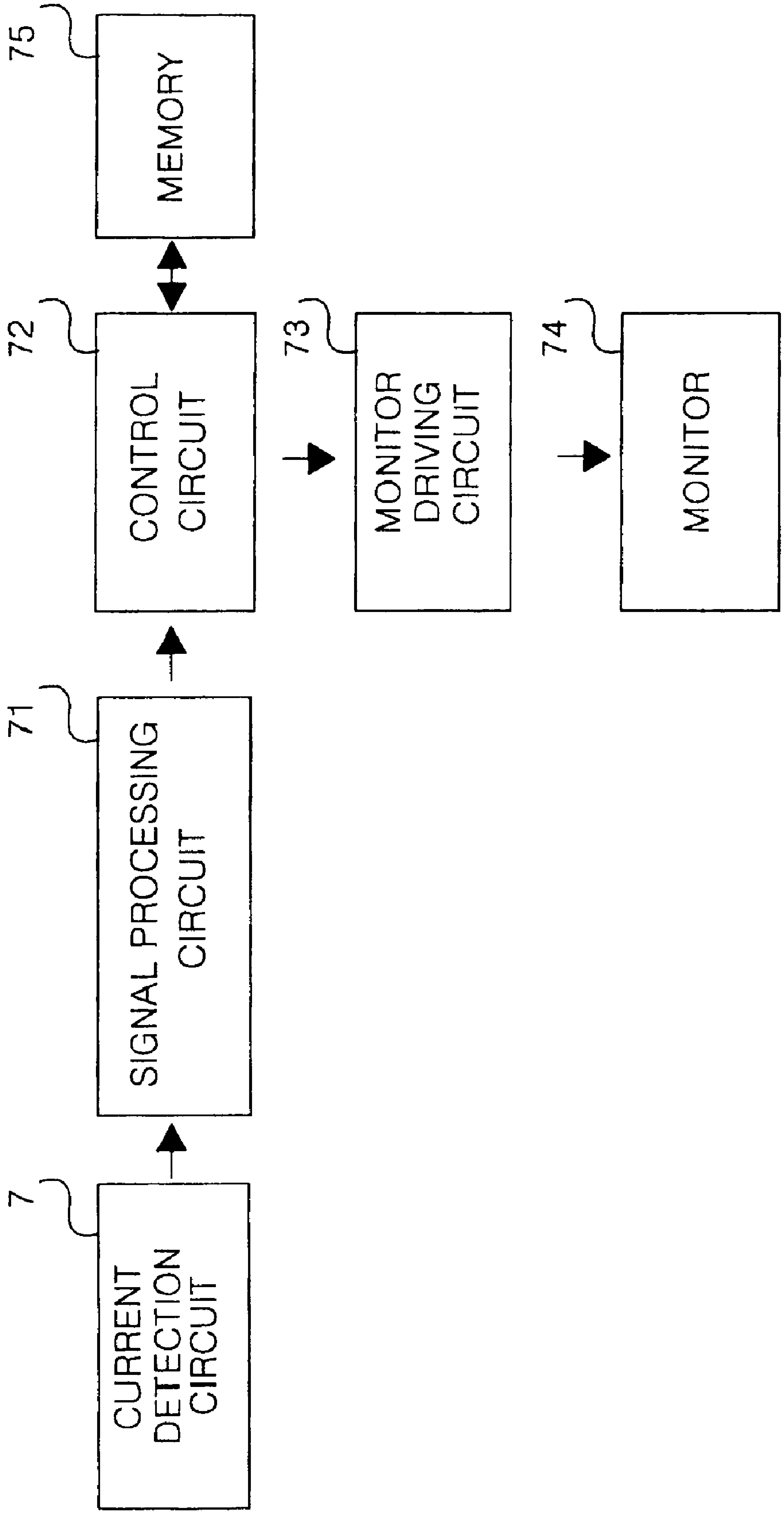
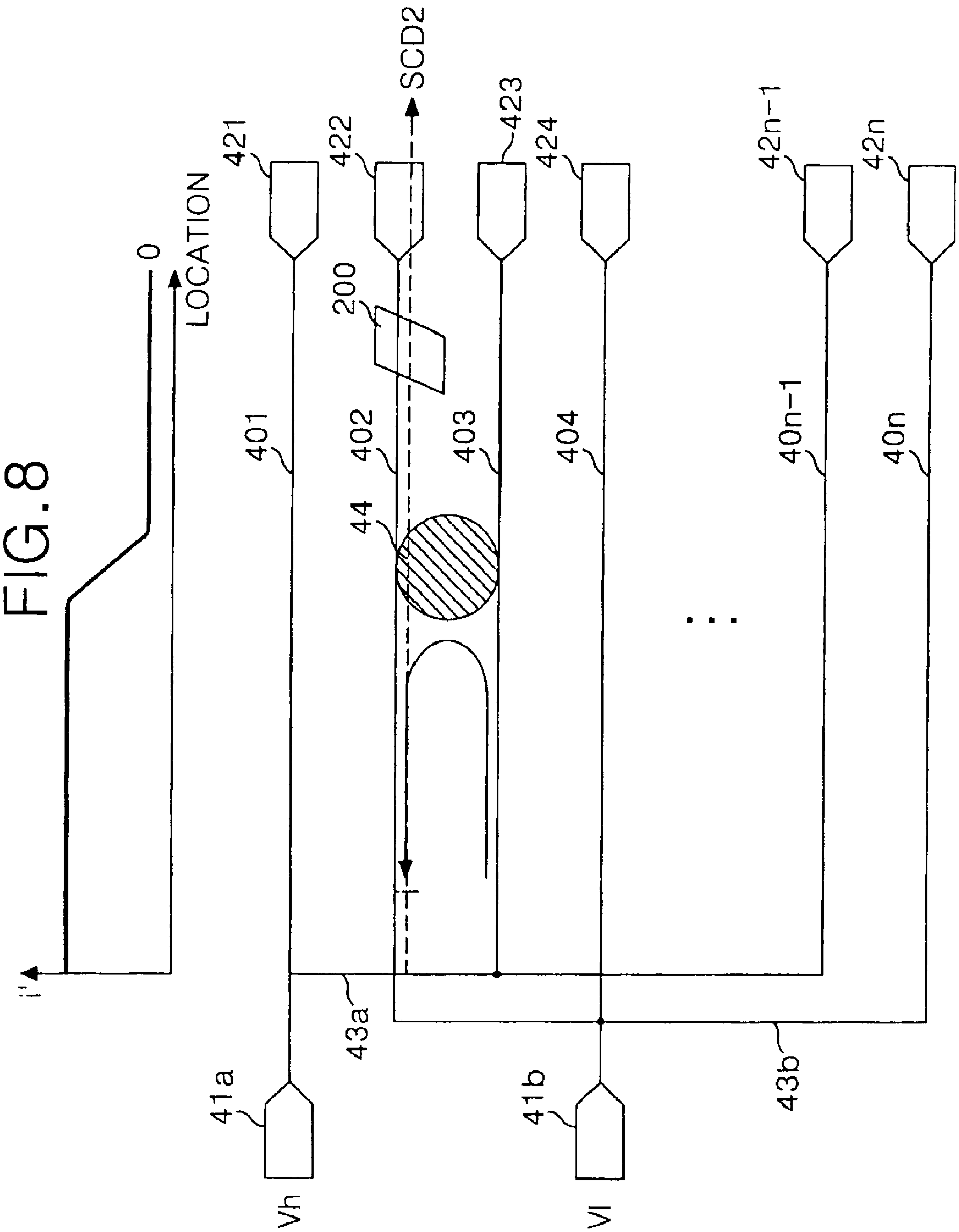


FIG. 7



7
CURRENT DETECTION CIRCUIT
71
SIGNAL PROCESSING CIRCUIT
72
CONTROL CIRCUIT
75
MEMORY
73
MONITOR DRIVING CIRCUIT
74
MONITOR

FIG. 8


i'
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LOCATION
SCD2
421
422
423
424
42n-1
42n
200
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402
403
404
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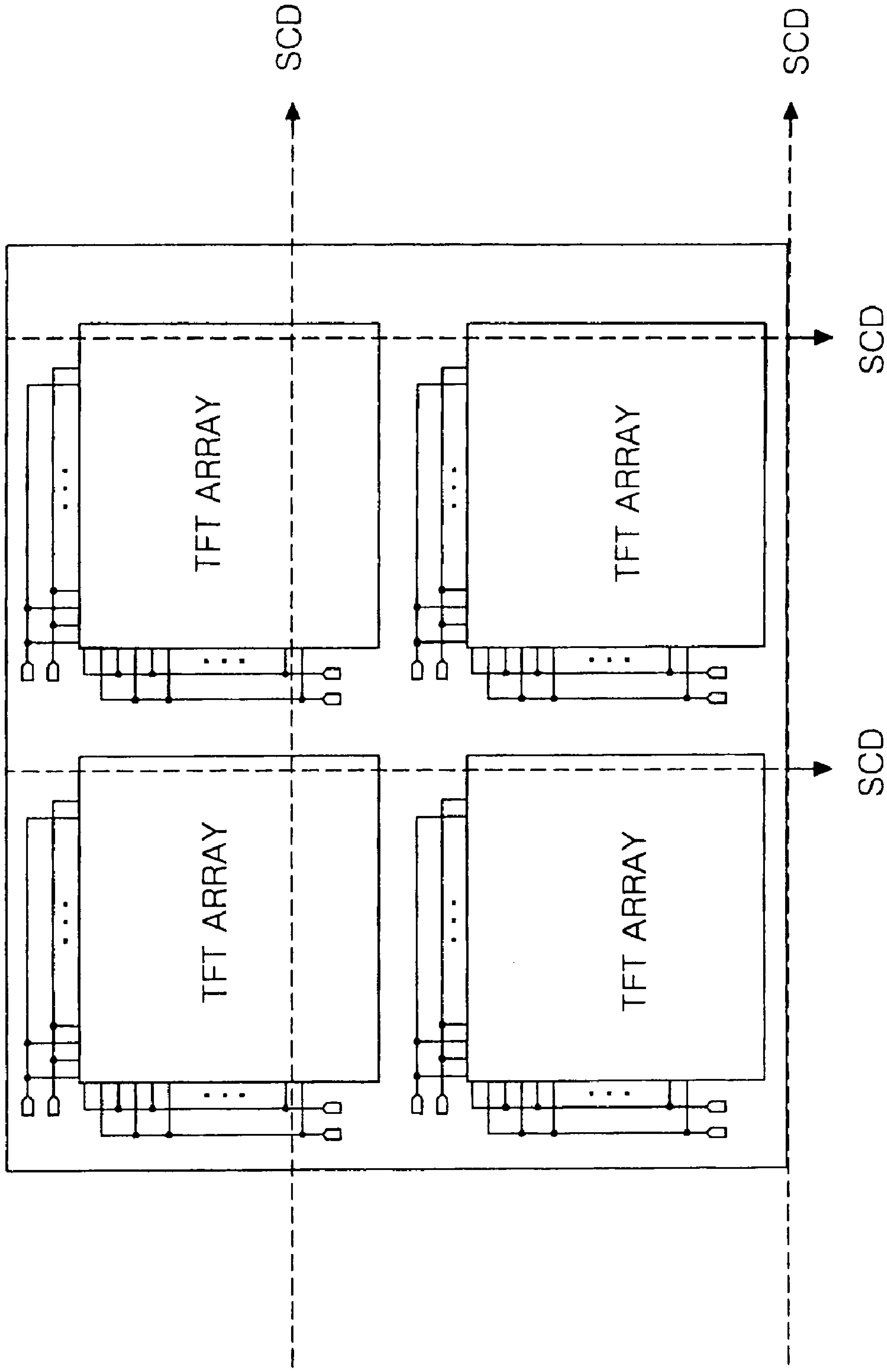
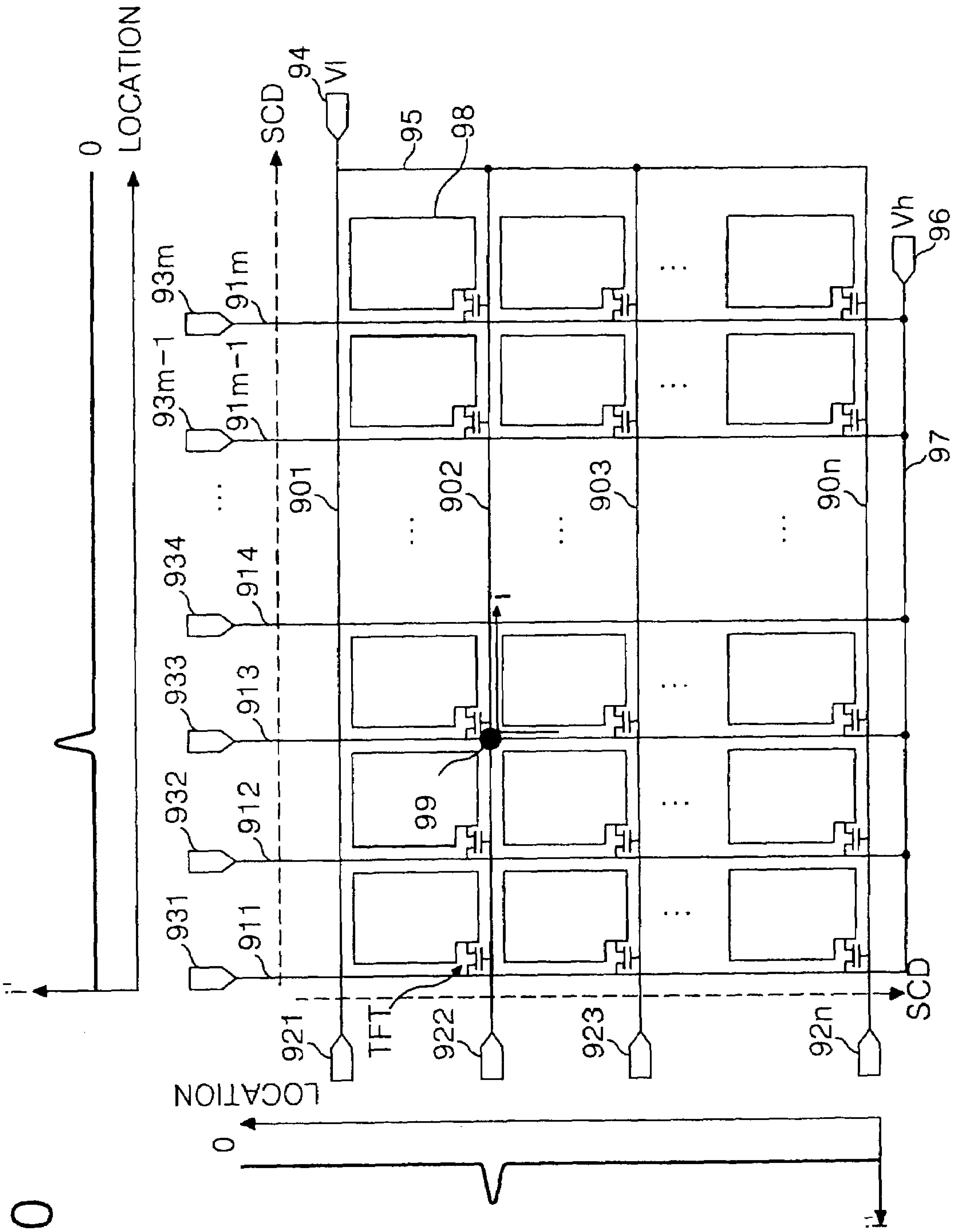
40n
44
43a
43b
41a
41b
Vh
Vl

FIG.9




LOCATION
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94
Vl
95
98
Vh
96
93m
91m
93m-1
91m-1
97
901
902
903
90n
934
914
933
913
932
912
931
911
99
921
TFT
922
923
92n
SCD
LOCATION
0
i
i

FIG.10

FIG.11

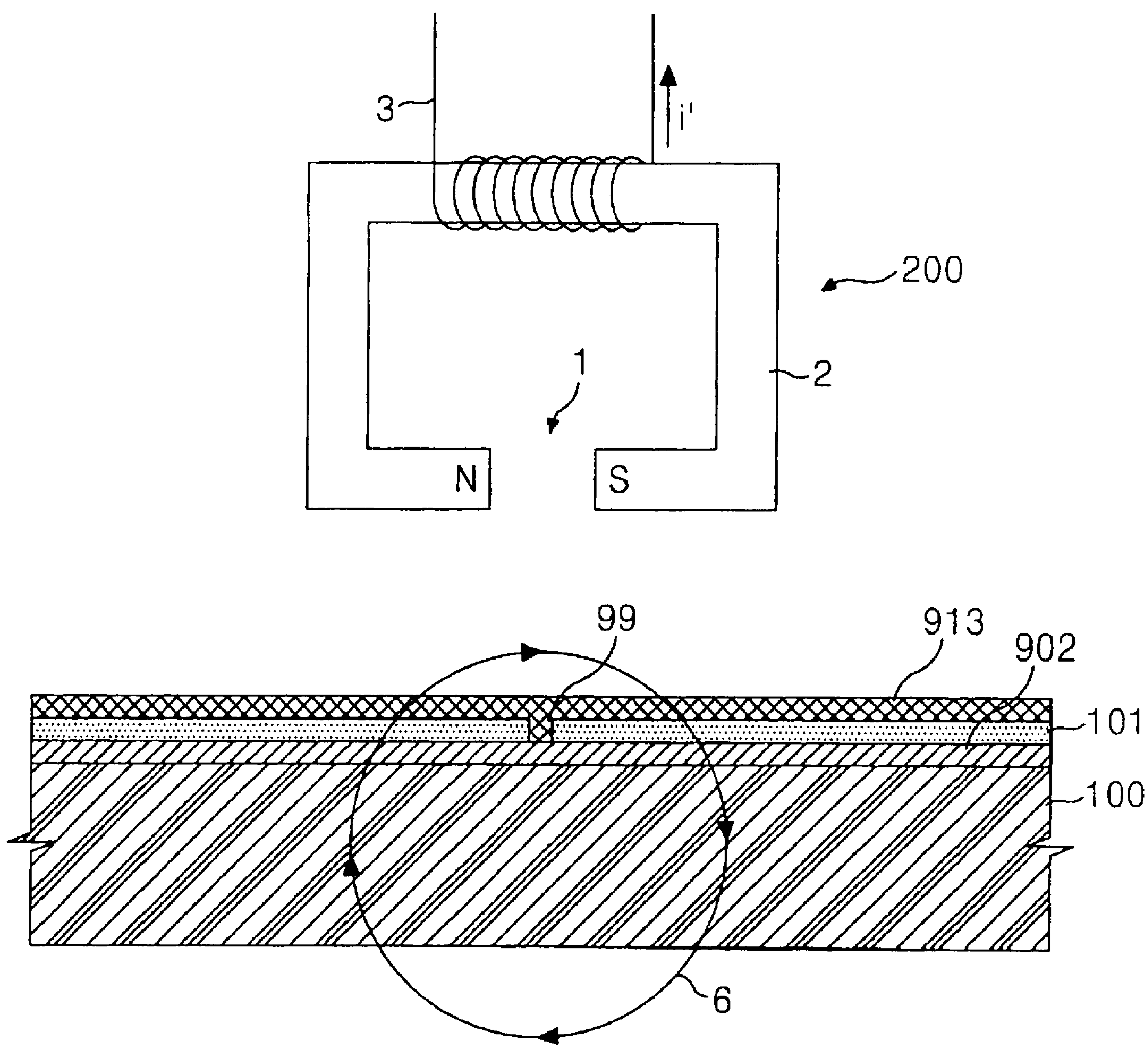


FIG.12

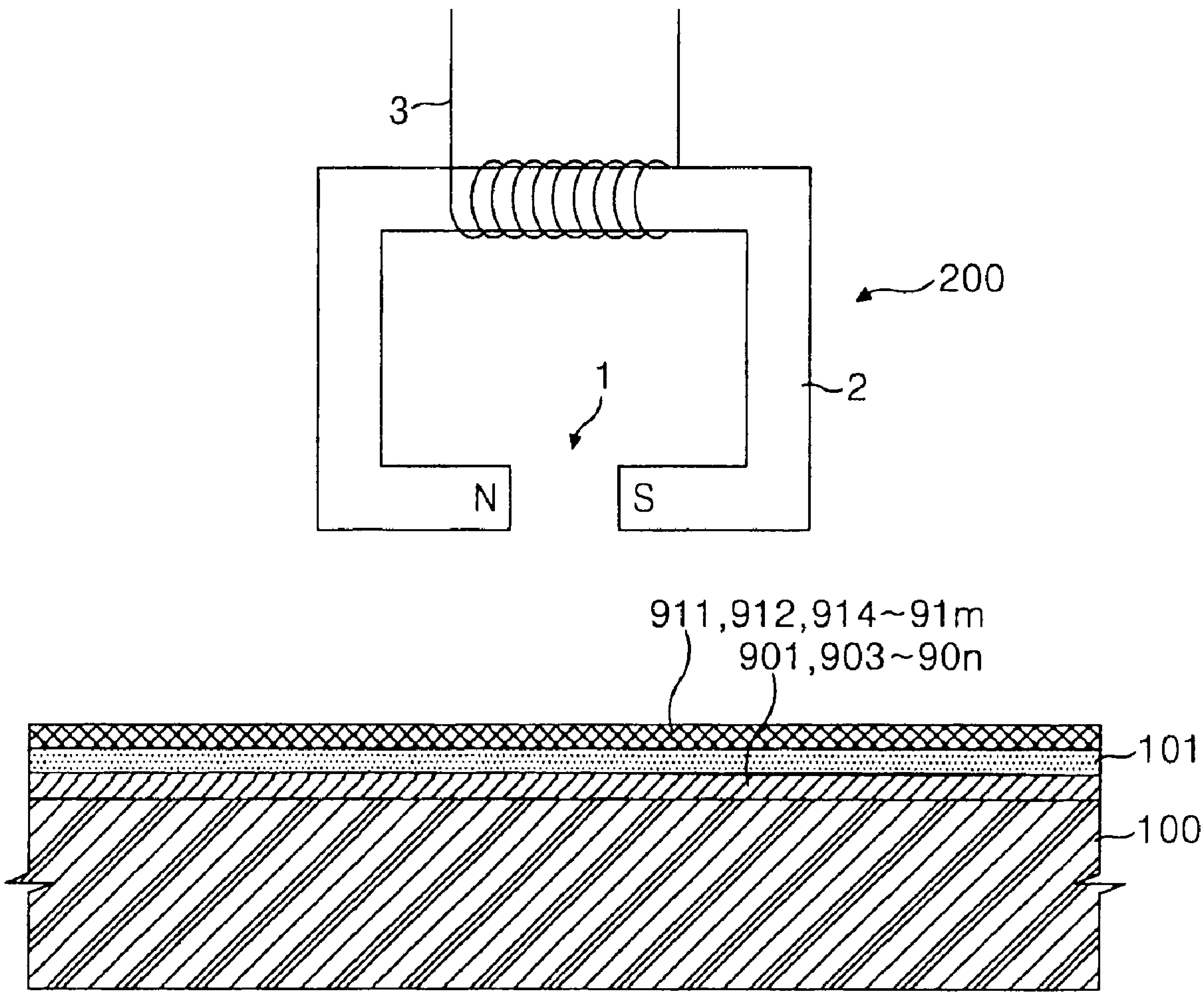


FIG. 13

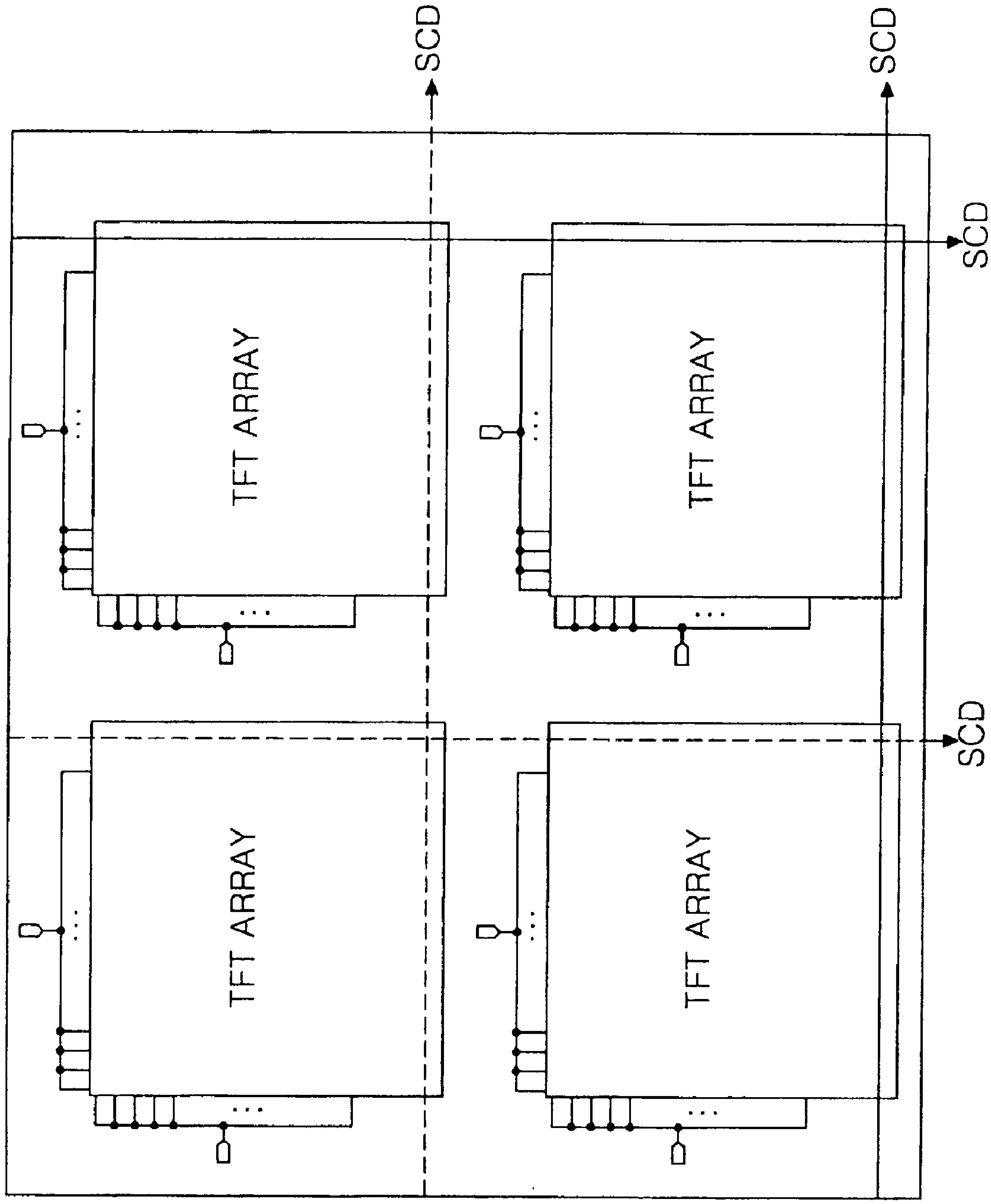
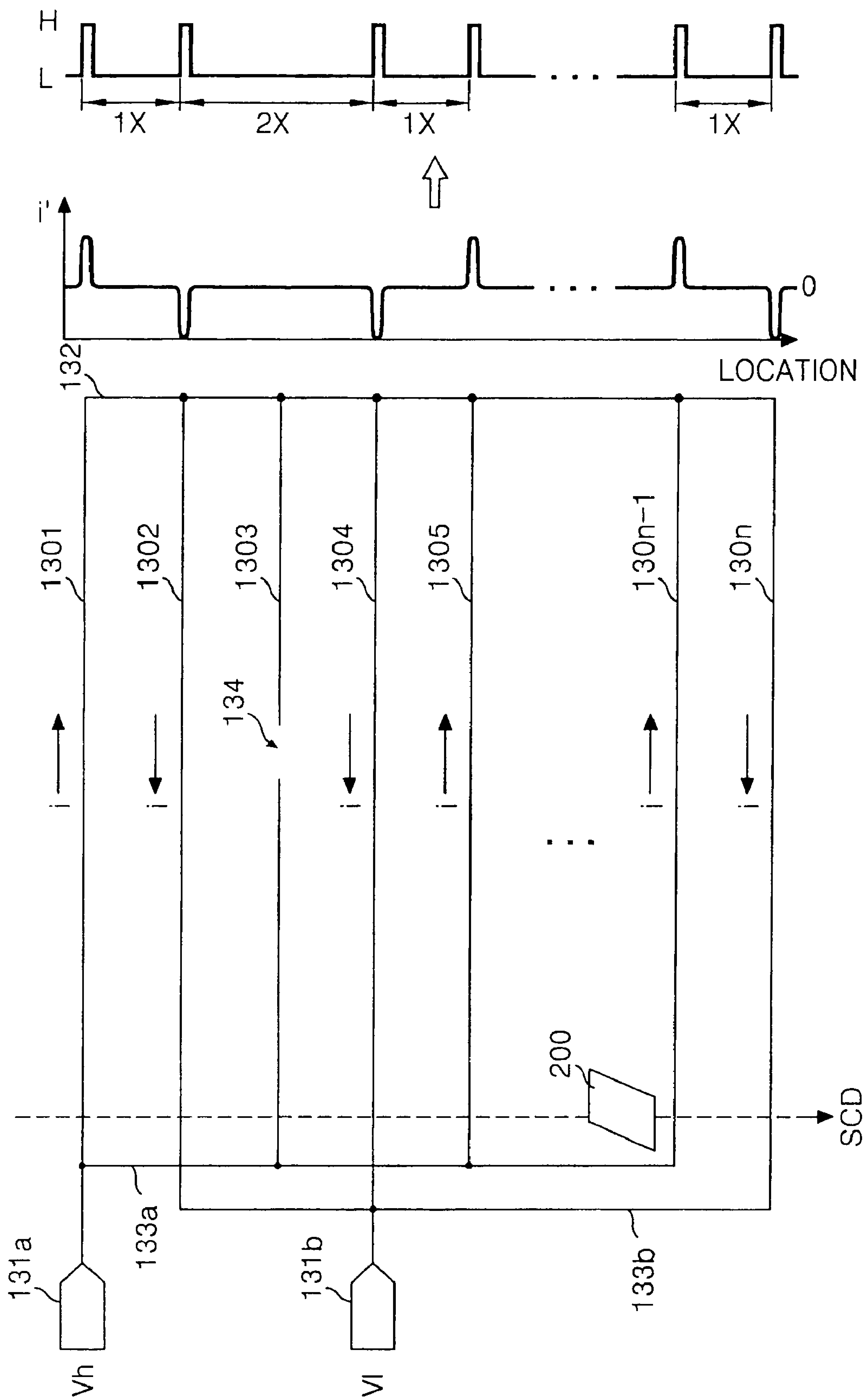


FIG.14


H
L
1X
2X
1X
1X
i'
0
LOCATION
132
1301
1302
1303
1304
1305
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130n
134
i
200
SCD
133a
133b
131a
131b
Vh
Vl

FIG. 15

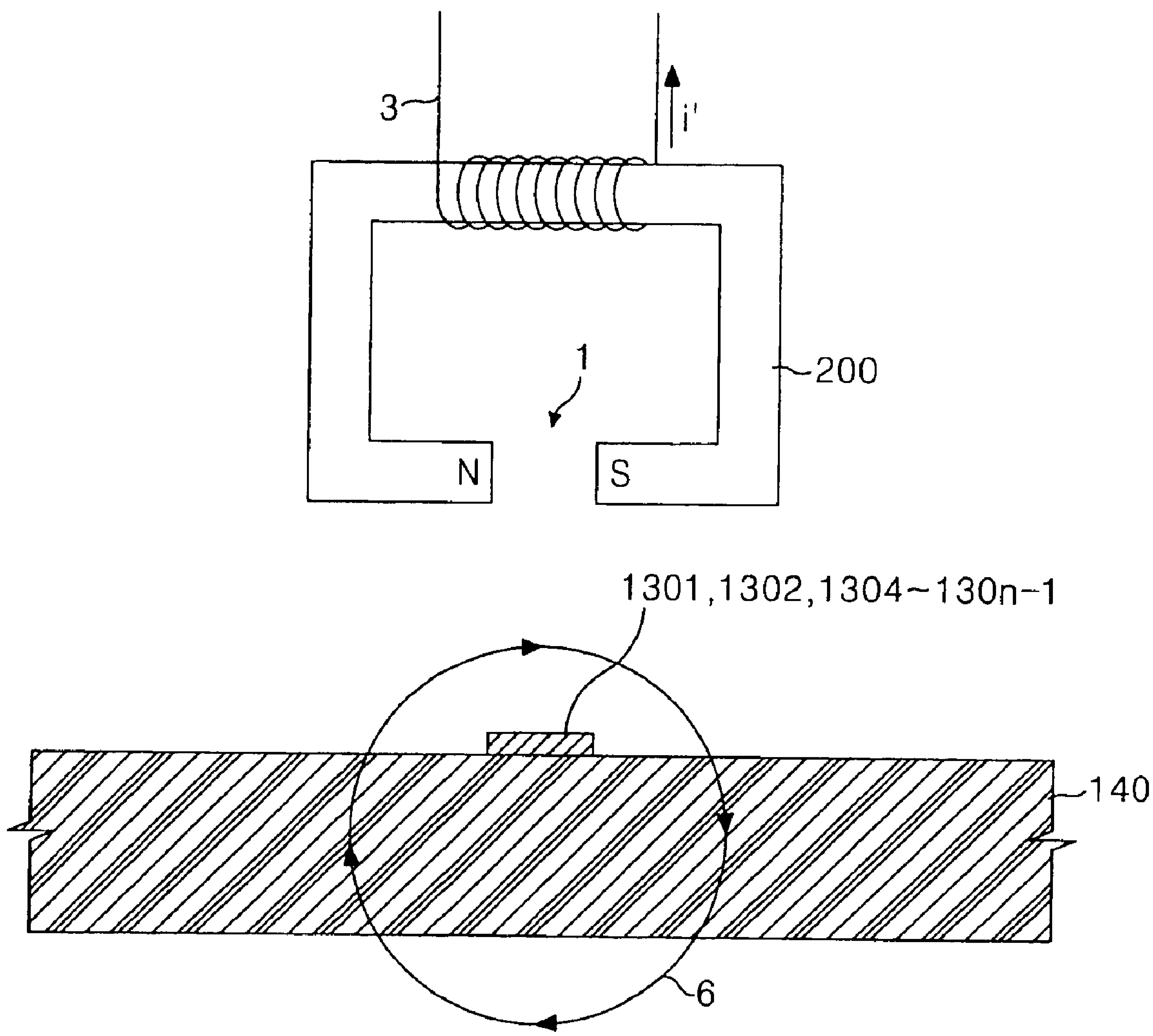


FIG.16

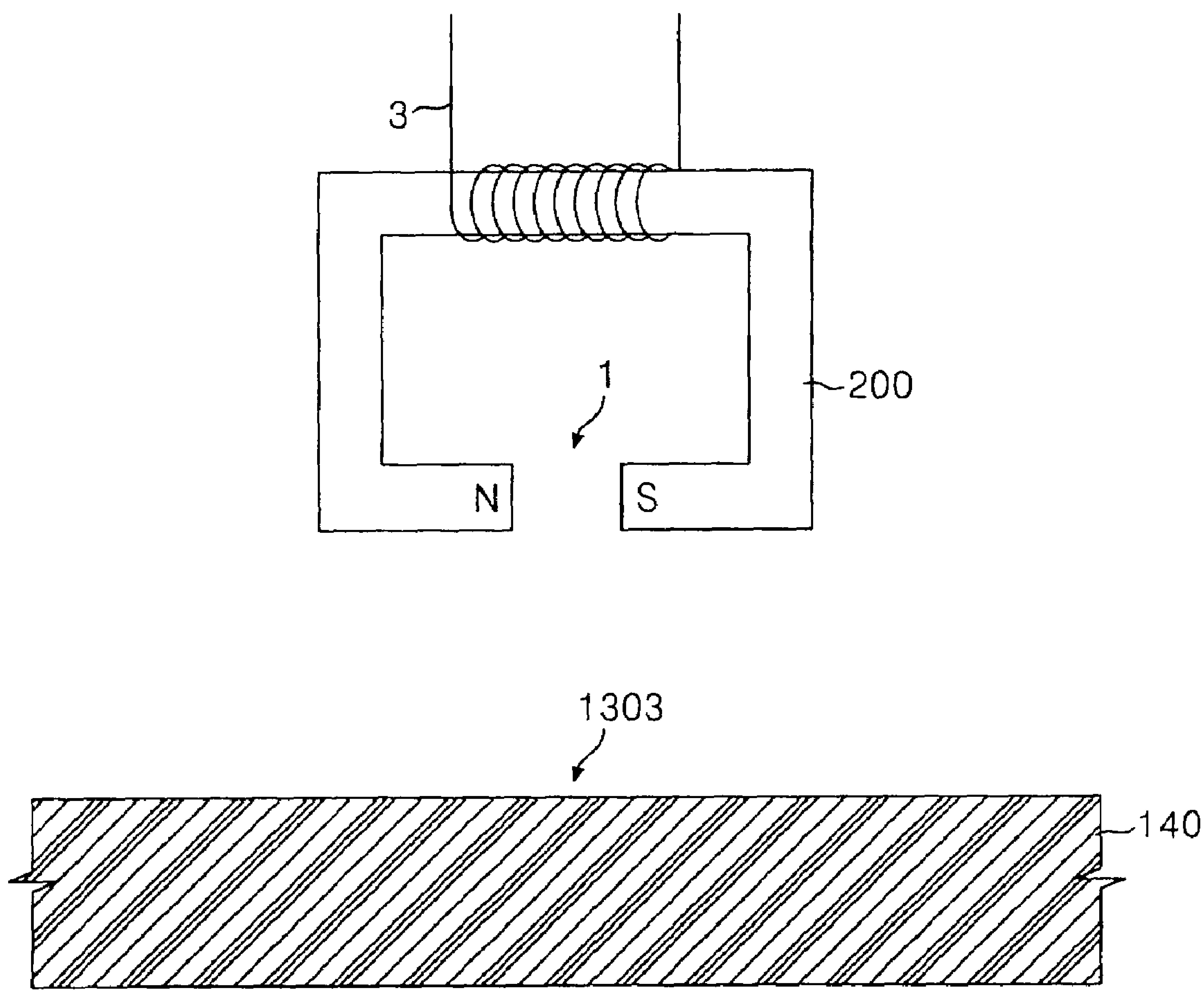


FIG.17

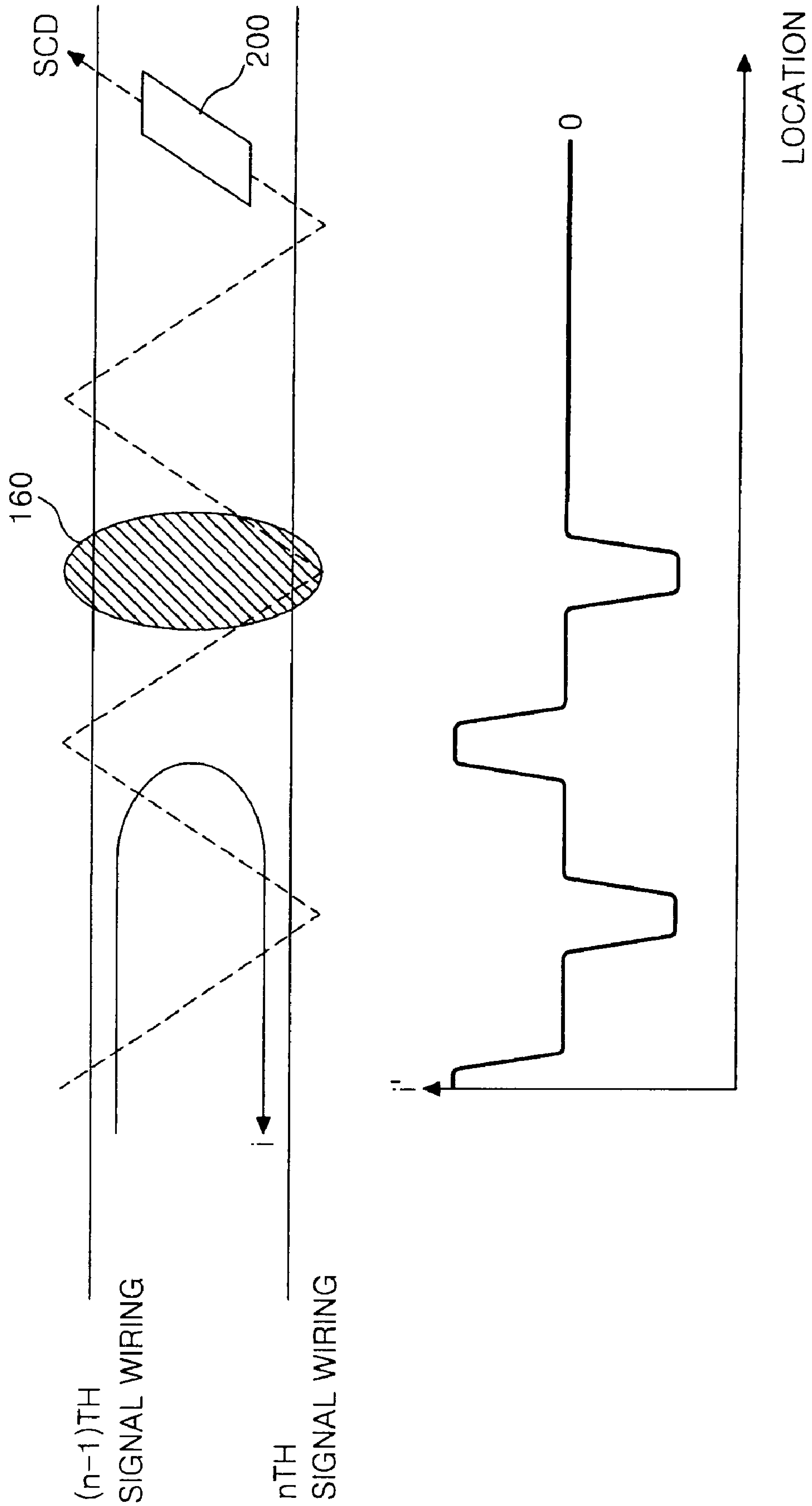
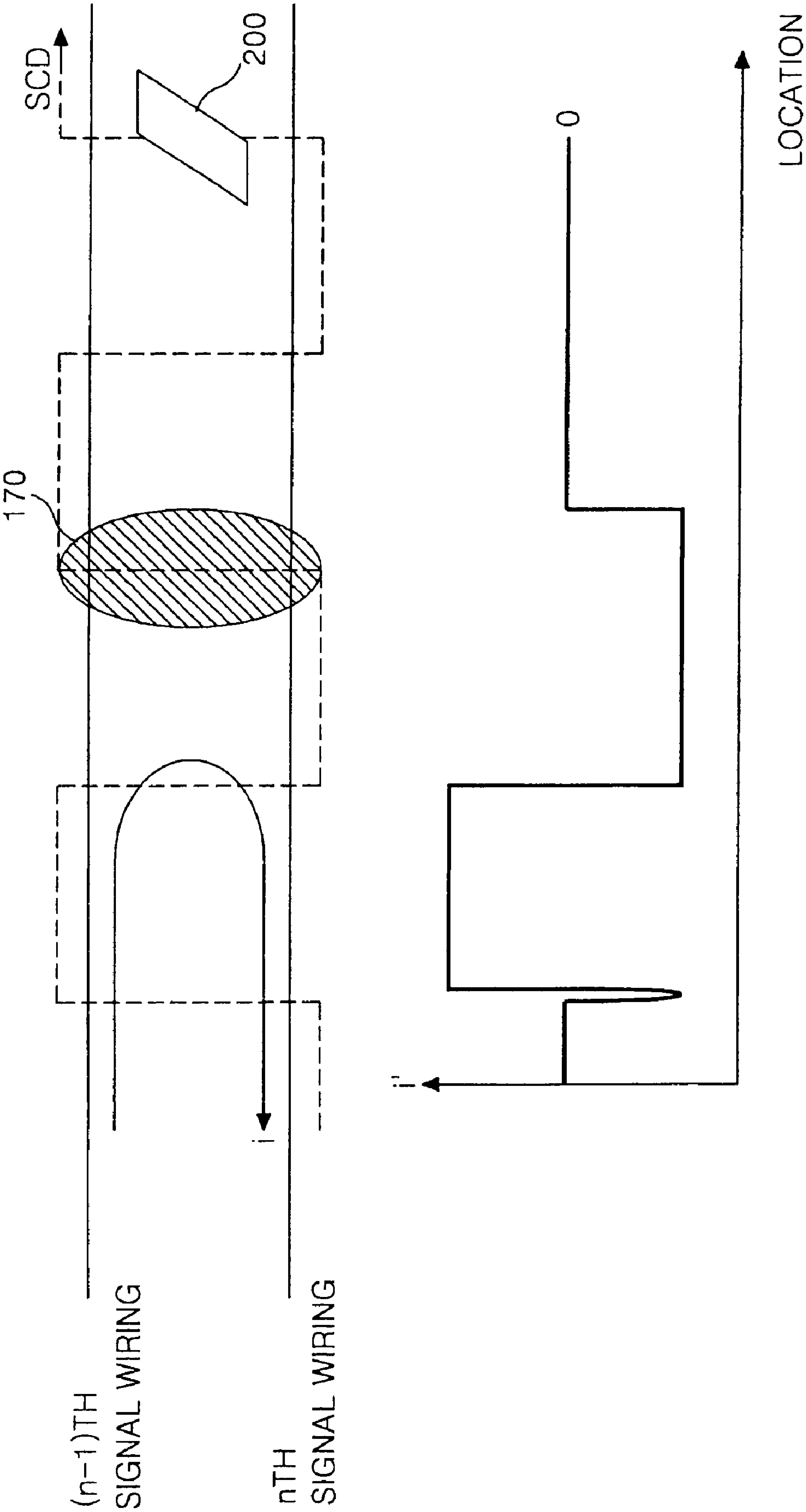

SCD
200
160
0
LOCATION
i
i
(n-1)TH
SIGNAL WIRING
nTH
SIGNAL WIRING

FIG.18


SCD
200
170
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LOCATION
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(n-1)TH
SIGNAL WIRING
nTH
SIGNAL WIRING

METHOD AND APPARATUS FOR TESTING FLAT DISPLAY APPARATUS

This application claims priority under 35 U.S.C. §119 of Korea P2003-28641, filed May 6, 2003, the entire contents of which is hereby incorporated by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention pertains to a flat display apparatus, and more particularly to a method and apparatus that inspects for shorts and open circuits in the signal wires of a flat display apparatus by using a magnetic sensor.

2. Description of the Related Art

The importance of a display apparatus as a visual information transfer medium has recently enlarged. Widely used conventional cathode ray tubes have undesirable weight and large volume. There has therefore been developed various types of flat display apparatuses capable of overcoming the disadvantages of cathode ray tubes.

Examples of currently commercially available flat panel displays include a liquid crystal display (LCD), a field emission display (FED), a plasma display panel (PDP) and an electroluminescence display (EL).

The liquid crystal display device readily adapts for miniaturization and has the additional advantage of improved productivity. Thus, LCDs are fast replacing the cathode ray tube in many applications.

Specifically, an active matrix type liquid crystal display apparatus that drives a liquid crystal cell by using a thin film transistor (hereinafter referred to as "TFT") has an advantage of excellent picture quality combined with low power consumption. This technology has rapidly developed to large volume production of high definition displays due to recent research and the application of productivity technology.

The process for fabricating an active matrix type liquid crystal display apparatus is divided into substrate cleaning, substrate patterning, alignment forming/rubbing, substrate assembling/liquid crystal material injecting, mounting, inspecting, repairing, etc.

Impurities on a substrate surface of the liquid crystal display during the substrate cleaning process are removed by a detergent.

The substrate patterning process includes patterning of an upper substrate, i.e., a color filter substrate and a patterning of a lower substrate of, for example, a TFT array substrate. There are formed a color filter, a common electrode, a black matrix, etc. on the upper substrate. There are also formed signal wires such as a data line and a gate line on the lower substrate. The TFT is formed at an intersection of the data line and the gate line, and a pixel electrode is formed in a pixel region between the gate line and the data line connected to a source electrode of the TFT.

An alignment film is applied to each of the upper substrate and the lower substrate during the alignment film forming/rubbing process, and the alignment film is rubbed by a rubbing material.

During the substrate assembling/the liquid crystal injection process, both of the upper substrate and the lower substrate are bonded together with a sealant, and the liquid crystal material and a spacer are injected through a liquid crystal injection hole. Then, the liquid crystal injection hole is sealed.

The mounting process of the liquid crystal panel uses a tape carrier package (hereinafter referred to as "TCP") having integrated circuits mounted thereon, such as a gate drive integrated circuit and a data drive integrated circuit connected to a pad part on the substrate. Such integrated driving circuits may be directly mounted on the substrate by using a chip on glass (herein after referred to as "COG") method other than TAB (Tape Automated Bonding) using the TCP described above.

The inspecting process includes a first electrical inspection performed after a variety of signal wires and the pixel electrode are formed. An electrical inspection and a visual inspection are performed after the substrate assembly/liquid crystal injection process. Specifically, the electrical inspection of the signal wire and the pixel electrode of the lower substrate, followed by the substrate assembling, may reduce the defect ratio and the amount of waste matter. Also, a bad substrate may be capable of repair at an early stage, and thus its importance gradually increases.

The repairing process performs a restoration of a repairable substrate that is determined during the inspecting process. However, in the inspecting process, bad substrates that are beyond repair are discarded.

The electrical inspection being performed before substrate assembly frequently employs a method using an apparatus shown in FIG. **1**.

Referring to FIG. **1**, the electrical inspection process is performed as follows: a separate modulator **10** has a designated gap over a test substrate **11**. Applying a test voltage (Vtest) to the modulator, while maintaining the gap, and detecting light reflected from the modulator **10** determines any electrical defects in the signal wires **17** and **18**.

In the modulator **10**, a polymer-dispersed liquid crystal (hereinafter referred to as "PDLC") is put between an upper transparent substrate **12**, having a common electrode **13**, and the lower transparent substrate **15**. In the modulator **10**, a reflection sheet **16** is placed toward a rear surface of the lower transparent substrate **15**. The modulator **10** has an air nozzle and a vacuum nozzle for an auto-gapping to maintain the designated interval from the detected substrate **11**.

Above the modulator **10**, a lens **21** light-gathers the light from a light source (not shown) into the modulator **10**, and the lens **21** additionally transmits the light **22** reflected from the modulator **10**.

The substrate **11** to be tested is the lower substrate on which is found the TFT, the signal wires **17** and **18** and the pixel electrode **20**, which form the active matrix type liquid crystal display apparatus. The test substrate **11** shown in FIG. **1** is an equivalent circuit showing a portion of the total TFT array.

The test substrate **11** is loaded below the modulator **10**, and then the modulator descends and performs the auto-gapping. Then, the electrical inspection begins. While the gap between the modulator **10** and the test substrate **11** is maintained at a pre-set effective gap, the light radiated from the light source (not shown) is light-gathered in the modulator **10** by the light-gathering lens, and the test voltage (Vtest) is simultaneously applied to the common electrode **13**. The test data is applied from a driving circuit to the data wire **17**, and a test scan signal is applied to the gate wire **18**. Then, an effective electric field is applied to the PDLC **14** between the common electrode **13** of the modulator **10** and the pixel electrode **20** to be tested.

When the electric field is not applied, the PDLC **14** causes the light to scatter. When the effective electric field (E) is applied, the liquid crystal orients according to the direction of the effective electric field (E) and causes the light to transmit. Accordingly, in the electrical inspection process, when the voltage is normally applied to the pixel electrode

20, the corresponding liquid crystal layer of the PDLC 14 causes the light 22 to transmit. When the voltage is not applied to the pixel electrode 20, the liquid crystal layer of the PDLC 14 causes the light to scatter in that part.

While the light 22 transmitting to the liquid crystal layer of the PDLC 14 is reflected on the reflection sheet 16 and is reverse directed to a light path, the light 22 scattered in the liquid crystal layer of the PDLC 14 nearly vanishes and is not nearly incident to the reflection sheet 16. The light reflected in the modulator 10 is received to a charge-coupled device (CCD) (not shown) via the lens 21 and then is converted to an electrical signal. The received signal converted electrically is then transferred to a display apparatus (not shown) via a signal processing circuit. A testing inspector monitors an image or data displayed in the display apparatus to determine whether it is bad or not. The testing inspector secondarily performs a close inspection of doubtful points the signal (data and gate) wires 17 and 18.

The modulator 10 also has an advantage of exactness and reliability capable of inspecting for defects pixel by pixel, but it has a defect of high price. Further, since the inspection region is narrow as compared with total substrate 11 area, the modulator 10 repeats the process of transferring by a designated length in a vertical or a horizontal direction, and then stopping temporarily for auto-gapping. There is thus the disadvantage that the inspection time becomes long. That is, as shown in FIG. 2, the modulator 10 scans the obliquely lined part smaller than the substrate 11 at the incipient location, and then moves and stops at an adjacent sub-block, and then performs auto-gapping and scanning. The stepping, the auto-gapping and the moving are repeated in the horizontal direction and in the vertical directions. For example, in order to entirely scan a substrate having a size of 14.1 inches (36 cm), the modulator repeats fourteen times the step of auto-gapping and then moving. Accordingly, the inspection method of using the modulator 10 has a disadvantageously long inspection time.

SUMMARY OF THE INVENTION

Accordingly, an object of the invention is to provide a method and apparatus to inspect a flat display apparatus for inspecting for a short or an open circuit in signal wires in a flat display device by using a magnetic sensor.

In order to achieve these and other objects of the invention, the invention includes, in part, an inspection method for a flat display device that entails scanning signal wires by using a magnetic sensor along a scan direction crossing a plurality of the signal wires and detecting at least one of a short or an open circuit in the signal wires based on a current of the signal wires detected by the magnetic sensor. The method also includes supplying a first common voltage to one side of odd-numbered signal wires within the plurality of signal wires, supplying a second common voltage different from the first common voltage to one side of even-numbered signal wires within the plurality of signal wires, and maintaining the other side of each of the signal wires in an insulated state. In the method, other steps can include detecting a short point by scanning the shorted signal wires along a second scan direction identical with a longitudinal direction of the signal wires, supplying a first common voltage to one side of odd-numbered signal wires, supplying a second common voltage different from the first common voltage to one side of even-numbered signal wires, and shorting the other side of each of the signal wires.

The invention, in part, pertains to an inspection method that includes providing a flat display device having at least one of first signal wires and at least one of second signal wires stacked on the first signal wire, and an insulation layer is located between the first and the second signal wires, scanning the second signal wires along a first scan direction crossing the first signal wires and a second scan direction crossing the second signal wires by using a magnetic sensor, and detecting an interlayer short on the signal wires based on a current of the signal wires detected by the magnetic sensor. The method can also include supplying a first common voltage to one side of the first signal wires, supplying a second common voltage different from the first common voltage to one side of the second signal wires, and maintaining an other side of each of the first and the second signal wires in an insulated state.

The invention, in part, pertains to an inspection method for a flat display device that includes scanning signal wires by using a magnetic sensor along the a scan direction proceeding in a zig-zag pattern, and detecting a short in the signal wires based on a current of the signal wires detected by the magnetic sensor. The method can also include supplying a first common voltage to one side of a first signal wire of the adjacent signal wires, supplying a second common voltage different from the first common voltage to one side of a second signal wire adjacent to the first signal wire, and maintaining the other side of each of the signal wires in an insulated state.

The invention, in part, pertains to an apparatus for inspecting a flat display device that includes a magnetic sensor for scanning on signal wires along a scan direction crossing a plurality of the signal wires, and a detection circuit for detecting at least one of a short or an open circuit on the signal wires, the detection circuit being formed based on current of the signal wires detected by the magnetic sensor. The magnetic sensor can be one of an inductive sensor, a giant magneto-resistance sensor, a magneto-resistance sensor, a tunneling magneto-resistance sensor or a fluxgate sensor. The apparatus can also include a first power supply for supplying the first common voltage to one side of odd-numbered signal wires, and a second power supply for supplying the second common voltage different from the first common voltage to one side of even-numbered signal wires. Also, another side of each of the signal wires is maintained in an insulated state during a short inspection of the signal wires. The magnetic sensor can perform a secondary scanning on at least one of the shorted signal wires along a second scan direction parallel with a longitudinal direction of the signal wires to locate a shorted point. Also, another side of each of the signal wires is shorted upon an open circuit inspection of the signal wires.

The invention, in part, pertains to an inspection apparatus for a flat display device having at least one of a first signal wire, an insulation layer over the first signal wire, and a second signal wire over the insulation layer, the inspection apparatus including a magnetic sensor for scanning the first and the second signal wires along a first scan direction crossing the first signal wire and a second scan direction crossing the second signal wire, and a detection circuit for detecting an interlayer short in the signal wires based on a current of the signal wires detected by the magnetic sensor. The magnetic sensor can be one of an inductive sensor, a giant magneto-resistance sensor, a magneto-resistance sensor, a tunneling magneto-resistance sensor or a fluxgate sensor. The apparatus can also have a first power supply for supplying a first common voltage to one side of the first signal wire, and a second power supply for supplying the second common voltage different from the first common voltage to one side of the second signal wire. Also, another side of each of the first and the second signal wires is maintained in an insulated state.

The invention, in part, pertains to an inspection apparatus for a flat display device that includes a magnetic sensor for scanning signal wires along a scan direction proceeding in a zig-zag pattern between adjacent signal wires, and a detection circuit for detecting a short on the signal wires based on a current of the signal wires detected by the magnetic sensor. The magnetic sensor can be one of an inductive sensor, a giant magneto-resistance sensor, a magneto-resistance sensor, a tunneling magneto-resistance sensor or a fluxgate sensor. The apparatus can also include a first power supply for supplying a first common voltage to one side of a first signal wire of the adjacent signal wires, and a second power supply for supplying a second common voltage different from the first common voltage to one side of a second signal wire adjacent to the first signal wire. Another side of each of the signal wires can be maintained in an insulated state.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings are included to provide a further understanding of the invention. The drawings illustrate embodiments of the invention and together with the description serve to explain the principles of the embodiments of the invention.

FIG. **1** is a perspective view of an apparatus for electrically inspecting a liquid crystal display according to the related art.

FIG. **2** schematically illustrates a block moving according to a step-by step inspection method performed in the inspection apparatus shown in FIG. **1**.

FIG. **3** illustrates an inductive sensor according to an embodiment of the present invention.

FIG. **4** illustrates an inspection method and an apparatus of the flat display apparatus according to a first embodiment of the present invention.

FIG. **5** is a cross sectional diagram illustrating an inductive sensor when current flows in the signal wire shown in FIG. **4**.

FIG. **6** is a cross sectional diagram illustrating an inductive sensor when current does not flow in the signal wire shown in FIG. **4**.

FIG. **7** illustrates a block diagram of an inspection apparatus in accordance with a preferred embodiment of the invention.

FIG. **8** illustrates secondary scanning of a shorted signal wire in an inspection method and apparatus of a flat display according to a first embodiment of the invention.

FIG. **9** illustrates a scan method performed on a substrate before being subjected to a scribing process in an inspection method and apparatus for a flat display according to a first embodiment of the invention.

FIG. **10** illustrates an inspection method and apparatus for a flat display according to a second embodiment of the present invention.

FIG. **11** is a cross sectional diagram illustrating an inductive sensor when current flows in the signal wire shown in FIG. **9**.

FIG. **12** is a cross sectional diagram illustrating an inductive sensor when current does not flow in the signal wire shown in FIG. **9**.

FIG. **13** illustrates a scan method performed on a substrate before being subjected to a scribing process in an inspection method and apparatus for a flat display according to a second embodiment of the invention.

FIG. **14** illustrates an inspection method and apparatus for a flat display according to a third embodiment of the invention.

FIG. **15** is a cross sectional diagram illustrating an inductive sensor when current flows in the signal wire shown in FIG. **13**.

FIG. **16** is a cross sectional diagram illustrating an inductive sensor when current does not flow in a signal wire shown in FIG. **13**.

FIG. **17** illustrates an inspection method and apparatus for a flat display according to a fourth embodiment of the invention.

FIG. **18** illustrates an inspection method and apparatus for a flat display apparatus according to a fifth embodiment of the invention.

DETAILED DESCRIPTION

Advantages of the invention will become more apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

Hereinafter, with reference to FIGS. **3** to **17**, preferred embodiments of the invention will be fully explained.

An inspection method and an apparatus according to the invention inspects for a short and an open circuit that can be generated in signal wires of a flat display device by using variety of magnetic sensors such as an inductive sensor, a giant magneto-resistance sensor (GMR), a magneto-resistance sensor (MR) or a fluxgate sensor. Among these sensors, the inductive sensor will be mainly explained. The invention, however, is not restricted to inductive sensors, and any appropriate magnetic sensor type can be used to practice the invention.

Referring to FIG. **3**, the inductive sensor includes a magnetic material **2** bent in order to face a gap **1** and a coil **3** wound on the magnetic material **2**.

When an external or an induced magnetic field is induced to the magnetic material **2**, both facing ends that form the gap **1** are magnetized with a polarity opposite from each other.

The coil **3** generates a current using the magnetic field induced in the magnetic material **2**.

If the inductive sensor scans the signal wire **5** of the flat display apparatus, the current i' generates in the coil **3** wound on the magnetic material **2** by the induced magnetic field **6** generated when the current flows in the signal wire **5**. The current i' flowing in the coil **3** is detected by a current detection circuit **7**.

In order to improve the precision of the inspection, the gap **1** of the inductive sensor is preferably set below the width of the signal wire **5** that will be inspected. For example, the gap **1** may be set within several μm to several tens of μm. The gap, however, is not restricted to this range and can be set, for example, to a sub-micron value or to a value in excess of about 100 μm.

Referring to FIG. **4**, the inspection method and the apparatus according to a first embodiment of the invention supplies a high common voltage Vh to one side of odd-numbered signal wires **401**, **403**, . . . , **40**_n_-1. A low common voltage Vl is supplied to one side of even-numbered signal wires **402**, **404**, . . . , **40**_n_. The signal wire **401** to **40**_n_ are scanned by inductive sensor **200** along the secondary direction SCD crossing the signal wires **401** to **40**_n_ to inspect the short of the signal wires **401** to **40**_n_.

As shown in FIG. **5** and FIG. **6**, the signal wires **401** to **40**_n_ are scan signal wires (or gate wires, low wires) formed on the substrate **45** of the flat display device or data signal wires (or column wires) crossing thereto.

The odd-numbered signal wires **401**, **403**, . . . , **40**_n_-1 are connected to a first shorting wire **43**_a_ on one side to make a short circuit that is electrically isolated from even-signal wires **402**, **404**, . . . , **40**_n_. The first shorting wire **43**_a_ connects to a first inspection pad **41**_a_ supplied with the high common voltage Vh. The even-signal wires **402**,**404**, . . . , **40**_n_ connect to a second shorting wire **43**_b_ on one side to make a short circuit electrically isolated from odd-signal wires **401**, **403**, . . . , **40**_n_1. The second shorting wire **43**_b_ is connected to a second inspection pad **41**_b_ supplied with a low common voltage Vl.

Signal pads **421** to **42**_n_ are formed at the other sides of the signal wires **401** to **40**_n_ respectively. The signal pads **421** to **42**_n_ are connected to an output terminal of a driving integrated circuit (not shown) in the TCP process or the COG process.

After the inspection process, the inspection pads **41**_a_ and **41**_b_ and the shorting wires **43**_a_ and **43**_b_ are separated from the TFT array substrate at the time of the scribing process.

During the short inspection on the signal wires **401** to **40**_n_, the inductive sensor **200** is scanned by a non-contacting method in accordance with a scan direction SCD crossing the signal wires **401** to **40**_n_. If the second and the third signal wires **402** and **403** become shorted due to impurities or to a bad pattern generated in the fabricating process as shown in FIG. **4**, the current i does not flow in the first signal wire **401** and the fourth to the n_{th} signal wires **404** to **40**_n_, but the current i flows via a short point **44** on the second and the third signal wires **402** and **403**. At this time, since a high voltage Vh is applied to the odd-numbered signal wires **401**, **403**, . . . , **40**_n_-1 and the low voltage Vl is applied to the even-numbered signal wires **402**, **404**, . . . , **40**_n_, the current i flows from the third signal wire **403** to the second signal wire **402**. Then, as shown in FIG. **5**, the current i flows between the second signal wire **402** and the third signal wire **403**, and thus a magnetic field **6** is induced in the inductive sensor **200**. Accordingly the current i' flows on the coil **3** of the inductive sensor **200** by the induced magnetic field **6**. On the other hand, as shown in FIG. **6**, the current i does not flow in the first signal wire **401** and the fourth to the n_{th} signal wires, and thus the magnetic field is not induced in the inductive sensor **200**.

As shown in FIG. **7**, the current detected by a current inspection circuit **7** is converted into a digital signal by a signal processing circuit **71** to be amplified and then displayed on a monitor under the control of the control circuit **72** and the monitor driving circuit **73**. Accordingly, an inspector sees the data displayed on the monitor and recognizes that the second and the third signal wires **402** and **403** are shorted. The control circuit **72** stores in a memory **75** the data provided from the signal driving circuit **73** and compares the data stored in the memory **75** to a reference data, i.e., a reference circuit to determine the short circuit in the signal wires.

After the shorted signal wire is detected, the inspector, as shown in FIG. **8**, scans the inductive sensor **200** along a scan direction SCD2 proceeding to the shorted second signal wire **402** or the third signal wire **403** and finds the shorted point having the changed current i' of the inductive sensor **200**.

As shown in FIG. **9**, the short inspection on the signal wires **401** to **40**_n_ may be carried out collectively with respect to the substrate, having a plurality of TFT array formed thereon, before the scribing process. Similar to the above case, the inductive sensor **200** detects the current flowing in the signal wire **401** to **40**_n_ by scanning along the scan direction SCD crossing the signal wires **401** to **40**_n_.

FIGS. **10** to **12** illustrate an inspection method for a flat display device according to a second embodiment of the invention. It shows an inspection method when the signal wires respectively formed on another layer are shorted.

Referring to FIG. **10**, the inspection method according to the second embodiment of the invention has the high common voltage Vh being supplied to one side of the data signal wires **911** to **91**_m_, and the low common voltage Vl is supplied to one side of scan signal wires **901** to **90**_n_ crossing the data signal wires **911** to **91**_m_.

The data signal wires **911** to **91**_m_ are connected to one side of a first shorting wire **97**. The first shorting wire **97** is connected to a first inspection pad **96** having the high common voltage (Vh) supplied. The signal pads **931** to **93**_m_ are formed at the other side of the data signal wires **911** to **91**_m_.

The scan signal wires **901** to **90**_n_ are connected to one side of a second shorting wire **95**. The second shorting wire **95** is connected to a second inspection pad **94** having the low common voltage Vl supplied. Scan pads **921** to **92**_n_ are formed at the other side of the scan signal wires **901** to **90**_n_.

The inspection pads **94** and **96**, and the shorting wires **95** and **97** are separated from the TFT array substrate during the scribing process after the inspection process.

When the flat display device is a liquid crystal display, a TFT is formed at each intersection of the data signal wires **911** to **91**_m_ and the scan signal wires **901** to **90**_n_. The TFT is turned on when the scan voltage higher than the TFT's threshold voltage is applied via the scan signal wires **901** to **90**_n_ to supply a data voltage on the data signal wires **911** to **91**_m_ to the pixel electrode **98**.

Further according to the inspection method of the flat display device according to the second embodiment of the invention, the inductive sensor **200** scans the data signal wires **911** to **91**_m_ along the scan direction SCD crossing the data signal wires **911** to **91**_m_, and additionally scans the inductive sensor **200** on the scan signal wires **901** to **90**_n_ along the scan direction SCD crossing the scan signal wires **901** to **90**_n_ to inspect an interlayer short between the signal wires **911** to **91**_m_, **901** to **90**_n_ respectively formed at a separate layer.

As shown in FIGS. **11** and **12**, the data signal wires **911** to **91**_m_ and the scan signal wires **901** to **90**_n_ are crossed on the substrate **100** by putting the insulation layer **101** between them.

During the interlayer short inspection between the data signal wires **911** to **91**_m_ and the scan signal wires **901** to **90**_n_, the inductive sensor **200** scans the scan signal wires **901** to **90**_n_ with a non-contacting method, and then scans with the non-contacting method the data signal wires **911** to **91**_m_. Alternately, the inductive sensor **200** may scan with non-contacting method along the data signal wires **911** to **91**_m_ and also may scan the scan signal wires **901** to **90**_n_. If the insulation layer **101** is lost at the location having the data signal wires **911** to **91**_m_ and the scan signal wires **901** to **90**_n_ cross, due to a defective depositing process patterning process, the data signal wires **911** to **91**_m_ and the scan signal wires **901** to **90**_n_ are apt to be shorted at that point. As shown in FIG. **11**, if the third data signal wire **913** and the second scan signal wire **902** are shorted, the low common voltage Vl is supplied to the scan signal wires **901** to **90***n*, and the high common voltage Vh is supplied to the data signal wire **911** to **91***m*. Accordingly, the current i flows between the third data signal wire **913** and the second scan signal wire **902** via the shorted point. The current i flows from the third data signal wire **913** to the second scan signal wire **902**. If the current flows like this, when the inductive sensor **200** scans the third data signal wire **913** and the second scan signal wire **902**, as shown in FIG. **10**, an induced magnetic field **6** forms in the inductive sensor **200**, and current i' begins to flow by being induced by the magnetic field **6**. At this time, relatively high current i' is detected in the current detection circuit **7** (see FIG. **7**). The control circuit **72** compares the current i detected by the current detection circuit **7** with a reference current set in advance. If the detected current i' is larger than the reference current, then an interlayer short has occurred.

On the other hand, if the low common voltage Vl is supplied to the scan signal wires **901** to **90***n* and the high common voltage Vh is supplied to the data signal wires **911** to **91***m*, as shown in FIG. **11**, and if a short point **99** does not exist between the first, the second, the fourth to the m_{th} data signal wires **911**, **912**, **914** to **91***m* and the first, the third to the n_{th} scan signal wires **901**, **903** to **90***n*, then the current i does not flow. Therefore, when the inductive sensor **200** scans the first, the second, the fourth to the m_{th} data pads **931**, **932**, **934** to **93***m* and the first, the third to the n_{th} scan signal pads **921**, **923** to **92***n*, the induced magnetic field **6** does not induced the inductive sensor **200**, and the nearly no current is detected in the current detection circuit **7**.

If the inductive sensor **200** detects the current i upon scanning the data signal wires **911** to **91***m* and detects the current i upon scanning the scan signal wires **901** to **90***n*, the exact location where the interlayer short point exists is detected.

As shown in FIG. **13**, the interlayer inspection between the data signal wires **911** to **91***m* and the scan signal wires **901** to **90***n* can be collectively carried out simultaneously, on the substrate containing TFT arrays, before the scribing process. In this case, the inductive sensor **200** detects the current and the resistance by scanning in the scan direction SCD proceeding along the data signal wires **911** to **91***m* and the scan signal wires **901** to **90***n*.

FIG. **14** to FIG. **16** are diagrams illustrating the inspection method and apparatus for a flat display device according to the third embodiment of the invention, and shows one example of inspecting for the opening of the signal wires.

Referring to FIG. **14**, in the inspection method and apparatus for a flat display device according to the third embodiment of the invention, the high common voltage (Vh) is supplied to one side of the odd-numbered signal wires **1301**, **1303**, . . . , **130***n*-1, and the low common voltage Vl is supplied to one side of the even-numbered signal wires **1302**, **1304**, . . . , **130***n*, causing the other side of the signal wires to be shorted.

As shown in FIGS. **15** and **16**, the signal wire **1301** to **130***n* are scan signal wires formed on the substrate **140** of the flat display apparatus or the crossing data signal wires.

The odd-numbered signal wires are connected to a first shorting wire **133***a*. The first shorting wire **133***a* is connected to the first inspection pad **131***a* having the high common voltage (Vh) supplied. The even-numbered signal wires **1302**, **1304**, . . . , **130***n* connect to the second shorting wire **133***b*. The second shorting wire **133***b* connects to the second inspection pad **131***b* supplied with the low common voltage Vl.

The signal wires **1301** to **130***n* are connected to the third shorting wire **132** at the side opposite to the one to be shorted. On the other hand, the signal wires **1301** to **130***n* may short a protection device for electrostatic discharge damage (not shown) (hereinafter referred to as "ESD"). The reason is that the electrostatic discharge damage protection devices are respectively connected to the signal wires **1301** to **130***n*.

The inspection pads **131***a* and **131***b*, and the shorting wires **131***a*, **131***b* and **132** perform the inspection process, and then they are separated from the TFT array substrate during the scribing process.

The inspection method and apparatus according to the third embodiment of the invention scans, using the inductive sensor **200**, the signal wires **1301** to **130***n* along the scan direction crossing the signal wires **1301** to **130***n* to inspect for the presence of open signal wires **1301** to **130***n*.

Upon the open inspection of the signal wires **1301** to **130***n*, the inductive sensor **200** scans the signal wires **1301** to **130***n*, using a non-contacting method, along the scan direction SCD crossing the signal wires **1301** to **130***n*. As shown in FIG. **14**, it is assumed that the third signal wires **1303** opens at an open point **134** due to an impurity produced during the fabricating process or a bad pattern. While the current i flows in the first, the second signal wires **1301** and **1302** and the fourth to the n_{th} signal wires **1304** to **130***n*, the current i does not flow by the open point **134** in the third signal wires **1303**. At this time, the direction of the current i flowing in odd-numbered signal wires **1301**, **1305**, . . . , **130***n*-1 and the direction of the current i flowing in the even-numbered signal wires **1302**, **1304**, . . . , **130***n* are opposite to each other. Then, as shown in FIG. **15**, the current i flows through the other signal wires **1301**, **1302**, **1304** to **130***n* except the third signal wire **1303**, and the magnetic field **6** is induced in the inductive sensor **200** so that the current i' flows in the coil **3** of the inductive sensor **200**.

In contrast, FIG. **15** shows the situation where the current i does not flow in the third signal wire **1303**, the magnetic field is not induced in the inductive sensor **200**. The current detection circuit **7** detects the current i' generated in the coil **3** of the inductive sensor **200**. That is, the length of time a low or high field in sensed during a scan varies uniformly (1×, 1×, 1×, etc.) if there is no open circuit. However, if an open circuit is sensed, the field will be in the low or high state for about twice the usual time period (e.g., 1×, 2×, 1×, 1× . . .). The 2× time period shows that an open circuit is present, as is shown in FIG. **14**.

The current i' detected by the current detection circuit **7** is converted into the digital signal by the signal processing circuit **71**, is amplified and then is displayed on the monitor **74** under the control the controlling circuit **72** and the monitor driving circuit **73**, as shown in FIG. **7**. When the detected current i' is smaller than the predetermined reference current, the controlling circuit **72** determines that the signal wire is opened. Accordingly, the inspector sees the data displayed on the monitor **74** and recognizes that the third signal wire **1303** is opened.

The open circuit inspection of the signal wires **1301** to **130***n*, as shown in FIG. **8**, can be collectively carried out on the substrate, having the TFT arrays, before the scribing process. In this case, the inductive sensor **200** detects the current flowing in the signal wires **1301** to **130**_n_ by scanning along the scan direction SCD crossing the signal wires **1301** to **130**_n_.

FIG. **17** illustrates the inspection method and apparatus for a flat display device according to a fourth embodiment of the invention.

Referring to FIG. **17**, the inspection method and apparatus according to the fourth embodiment of the invention supplies the high common voltage to one side of the $(n\text{-}1)_{th}$ signal wire, supplies the low common voltage to one side of the n_{th} signal wire, and inspects for openness of the signal wires by scanning in a zig-zag pattern the inductive sensor **200** on the $(n\text{-}1)_{th}$ signal wire and the n_{th} signal wire.

The signal wires are the scan signal wire or the data signal wire.

During the openness inspection on the signal wires, the inductive sensor **200** is scanned by the non-contacting method along the scan direction SCD proceeding in a zig-zag pattern between $(n\text{-}1)_{th}$ signal wire and n_{th} signal wire. If the inductive sensor **200** scans the interval of adjacent signal wires in a zig-zag pattern, the polarity of the current i' generated in the coil **3** in accordance with the direction of the current is periodically inverted. By the way, if $(n\text{-}1)_{th}$ signal wire and the n_{th} signal wire is opened at the short point **160** due to an impurity introduced during the fabricating process or a bad pattern, and the inductive sensor **200** passes over the short point **160**. Since the current i' does not flow in the $(n\text{-}1)_{th}$ signal wire and the n_{th} signal wire, the magnetic field is not induced in the inductive sensor **200**, and the current i' does not arise in the coil **3**.

During the openness inspection on the signal wires, if the inductive sensor **200** scans in a zig-zag pattern, the current i' generated in the coil **3** of the inductive sensor **200** does not arise after the short point **160** upon one time scan. Therefore, the inspector need not scan the signal wires more than two times and can precisely find the location where the short point **160** exists by only one time scan.

FIG. **18** illustrates the inspection method and the apparatus of the flat display apparatus according to a fifth embodiment of the invention.

Referring to FIG. **18**, according to the inspection method and apparatus for flat display device according to a fifth embodiment of the invention, the high common voltage is supplied to one side of the $(n\text{-}1)_{th}$ signal wire, and the low common voltage is supplied to one side of the n_{th} signal wire. The inspection proceeds in a straight direction parallel with the signal wire and then bends to a proceeding path in the vertical direction. The inductive sensor **200** scans on the $(n\text{-}1)_{th}$ signal wire and the n_{th} signal wire along the scan direction (SCD) proceeding to the signal wire adjacent to the vertical with respect to the proceeding path to inspect for the presence of shorts in the signal wires.

The signal wires contain the scan signal wire or the data signal wire.

During the short inspection of the signal wires, the inductive sensor **200** scans the $(n\text{-}1)_{th}$ signal wire using a designated interval and then scans the n_{th} signal wire by the designated interval. If the inductive sensor **200** scans the adjacent signal wires in a zig-zag pattern, the polarity of the current i' generated in the coil **3** periodically inverts in accordance with the direction of the current.

If the inductive sensor **200** passes over the short point **170**, since the current i' does not flow in the $(n\text{-}1)_{th}$ signal wire and the n_{th} signal wire, the magnetic field is not induced in the inductive sensor **200**, and the current i' does not arise in the coil **3**.

The inspector using this embodiment can exactly find the location where the short point **170** exists by using only one time scan.

As described above, the inspection method and apparatus for a flat display device according to the invention scans the magnetic sensor on the signal wires along the scan direction crossing the signal wires, or proceeds in a zig-zag pattern between the adjacent signal wires. As a result, the inspection method and the apparatus of the flat display apparatus according to the invention may rapidly and exactly finds defects such as a short circuit or an open circuit of the signal wire.

Although the present invention has been explained by the embodiments shown in the drawings described above, it should be understood to the ordinary skilled person in the art that the invention is not limited to the embodiments, but rather that various changes or modifications thereof are possible without departing from the spirit of the invention. Accordingly, the scope of the invention shall be determined only by the appended claims and their equivalents.

What is claimed is:

1. An inspection method for a flat display device, comprising:

scanning signal wires by using a magnetic sensor along a scan direction crossing a plurality of the signal wires; and

detecting at least one of a short or an open circuit in the signal wires based on a current of the signal wires detected by the magnetic sensor.

2. The inspection method according to claim **1**, wherein detecting the short on the signal wires includes:

supplying a first common voltage to one side of odd-numbered signal wires within the plurality of signal wires;

supplying a second common voltage different from the first common voltage to one side of even-numbered signal wires within the plurality of signal wires; and

maintaining the other side of each of the signal wires in an insulated state.

3. The inspection method according to claim **1**, wherein detecting the short on the signal wires includes:

detecting a short point by scanning the shorted signal wires along a second scan direction identical with a longitudinal direction of the signal wires.

4. The inspection method according to claim **1**, wherein detecting the open circuit on the signal wire includes:

supplying a first common voltage to one side of odd-numbered signal wires;

supplying a second common voltage different from the first common voltage to one side of even-numbered signal wires; and

shorting the other side of each of the signal wires.

5. An inspection method, which comprises:

providing a flat display device having at least one of first signal wires and at least one of second signal wires stacked on the first signal wire, and an insulation layer is located between the first and the second signal wires;

scanning the second signal wires along a first scan direction crossing the first signal wires and a second scan direction crossing the second signal wires by using a magnetic sensor; and

detecting an interlayer short on the signal wires based on a current of the signal wires detected by the magnetic sensor.

6. The inspection method according to claim 5, further comprising:
supplying a first common voltage to one side of the first signal wires;
supplying a second common voltage different from the first common voltage to one side of the second signal wires; and
maintaining an other side of each of the first and the second signal wires in an insulated state.

7. An inspection method for a flat display device, comprising:
scanning signal wires by using a magnetic sensor along a scan direction proceeding in a zig-zag pattern; and
detecting a short in the signal wires based on a current of the signal wires detected by the magnetic sensor.

8. The inspection method according to claim 7, further comprising:
supplying a first common voltage to one side of a first signal wire of adjacent signal wires;
supplying a second common voltage different from the first common voltage to one side of a second signal wire adjacent to the first signal wire; and
maintaining the other side of each of the signal wires in an insulated state.

9. An apparatus for inspecting a flat display device, comprising:
a magnetic sensor for scanning on signal wires along a scan direction crossing a plurality of the signal wires; and
a detection circuit for detecting at least one of a short or an open circuit on the signal wires, the detection circuit being formed based on current of the signal wires detected by the magnetic sensor.

10. The apparatus according to claim 9, wherein the magnetic sensor comprises one of an inductive sensor, a giant magneto-resistance sensor, a magneto-resistance sensor, a tunneling magneto-resistance sensor or a fluxgate sensor.

11. The apparatus according to claim 9, further comprising:
a first power supply for supplying a first common voltage to one side of odd-numbered signal wires; and
a second power supply for supplying the second common voltage different from the first common voltage to one side of even-numbered signal wires.

12. The apparatus according to claim 11, wherein an other side of each of the signal wires is maintained in an insulated state during a short inspection of the signal wires.

13. The apparatus according to claim 9, wherein the magnetic sensor performs a secondary scanning on at least one of the shorted signal wires along a second scan direction parallel with a longitudinal direction of the signal wires to locate a shorted point.

14. The apparatus according to claim 11, wherein an other side of each of the signal wires is shorted upon an open circuit inspection of the signal wires.

15. An inspection apparatus for a flat display device having at least one of a first signal wire, an insulation layer over the first signal wire, and a second signal wire over the insulation layer, the inspection apparatus comprising:
a magnetic sensor for scanning the first and the second signal wires along a first scan direction crossing the first signal wire and a second scan direction crossing the second signal wire; and
a detection circuit for detecting an interlayer short in the signal wires based on a current of the signal wires detected by the magnetic sensor.

16. The inspection apparatus according to claim 15, wherein the magnetic sensor is one of an inductive sensor, a giant magneto-resistance sensor, a magneto-resistance sensor, a tunneling magneto-resistance sensor or a fluxgate sensor.

17. The inspection apparatus according to claim 15, further comprising:
a first power supply for supplying a first common voltage to one side of the first signal wire; and
a second power supply for supplying a second common voltage different from the first common voltage to one side of the second signal wire.

18. The inspection apparatus according to claim 17, wherein an other side of each of the first and the second signal wires is maintained in an insulated state.

19. An inspection apparatus for a flat display device, comprising:
a magnetic sensor for scanning signal wires along a scan direction proceeding in a zig-zag pattern between adjacent signal wires; and
a detection circuit for detecting a short on the signal wires based on a current of the signal wires detected by the magnetic sensor.

20. The inspection apparatus according to claim 19, wherein the magnetic sensor is one of an inductive sensor, a giant magneto-resistance sensor, a magneto-resistance sensor, a tunneling magneto-resistance sensor or a fluxgate sensor.

21. The inspection apparatus according to claim 19, further comprising:
a first power supply for supplying a first common voltage to one side of a first signal wire of the adjacent signal wires; and
a second power supply for supplying a second common voltage different from the first common voltage to one side of a second signal wire adjacent to the first signal wire.

22. The inspection apparatus according to claim 21, wherein an other side of each of the signal wires is maintained in an insulated state.

23. The inspection method according to claim 5, wherein the magnetic sensor has a gap that is less than a width of the signal wires.

24. The apparatus according to claim 15, wherein the magnetic sensor has a gap that is less than a width of the signal wires.

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